WHY ARE DIVIDENDS STICKY?

A Dissertation

by

CHUN-LI TSAI

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2005

Major Subject: Economics

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ABSTRACT

Why Are Dividends Sticky? (August 2005)

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This dissertation investigates the sluggish adjustment process of dividend payment in the stock market. First, I focus on the individual stocks. A casual investigation of observed dividends for individual stocks shows dividend adjustments are sluggish and discrete; this is not consistent with the Lintner's stylized fact (1956) in which dividend adjustments are assumed to change continuously. Thus, I examine three possible explanations to account for dividend stickiness and discreteness: menu-costs (i.e. a constant adjustment cost), decision-making delays, and dividend adjustment asymmetry. I reject Dixit's menu-cost model as an appropriate specification for the sluggish adjustment process of dividends. The empirical results imply that decision-making delays and dividend adjustment asymmetry might be possible explanations for sticky and discrete dividends on selected individual stocks.

Second, I focus on the aggregate stock market. I use a quadratic adjustment cost model to examine whether adjustment costs can explain the slow adjustment of aggregate dividends. The empirical results suggest that adjustment costs might be a significant factor explaining the slow dividend adjustment for S&P 500. The value of relative weigh cost is related to the specification of target dividend. If target dividends

are related to earnings, then the empirical results suggest that the adjustment costs are about forty-fold more important than the deviation cost between the actual dividend and the target level in determining the dynamic dividend adjustment process. If target dividends are specified as proportion to the stock prices, the adjustment costs are about fourteen-fold more important than the deviation cost between actual dividend and target level when managers determine the dividends.

DEDICATION

To my parents

ACKNOWLEDGMENTS

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CHAPTER I

INTRODUCTION

In financial markets, the determinants of dividend payout rates are still not well understood. However, dividend-smoothing behavior in the stock market identified by Lintner (1956) is fairly widespread. There have been several attempts in the literature to find and explain the observed patterns of dividend payout.

Lintner (1956) listed some stylized facts of dividend policies he discovered in interviews with corporate managers. These stylized facts are summarized as follows: (i) Most managers appeared to have in mind a target dividend and a long-run target payout ratio when they set dividends; (ii) Most managers wanted to avoid adjusting dividends; (iii) Many managers smooth dividend payouts in terms of current and past earnings. Lintner provided the first empirical specification of corporate dividend policy---"the partial adjustment process" to describe dividend adjustment behavior[1]. This adjustment process assumes managers adjust their dividends to the target levels. Lintner (1956), Fama and Harvey (1968) found earnings were the most important determinant of a change in dividends, and therefore specified target dividends as some percentage r (long-run target payout ratio) of earnings; Marsh and Merton (1987) and Kao and Wu

This dissertation follows the style and format of Journal of Monetary Economics.

[1] Lintner (1956) suggested that corporate dividend decisions can be explained by the following partial adjustment process,

$$\Delta d_t = b(d_t^* - d_{t-1})$$

where b is the speed of adjustment coefficient, $0 < b < 1$, and d_t^* is the target dividend.

(1994) extended Lintner's findings and proposed that dividend payouts are determined by permanent earnings, that is, target dividends are specified as some percentage r of permanent earnings.

From Lintner's list of stylized facts, dividend adjustments are assumed to be continuous with respect to the stochastic variations of the target dividend, defined by either earnings or permanent earnings. However, even a casual investigation of observed dividends for individual stocks shows that dividend adjustments are sluggish and discrete. The claim that dividends are smoothed over time is hardly controversial, but few studies examine the determinants of dividend smoothing and even fewer focus on the discreteness of the dividend adjustment process. Thus, the initial motivation of this research is to investigate the factors that could account for sticky and discrete dividends for individual stocks.

Kumar and Lee (2001) developed the first empirical paper to investigate a discrete dividend adjustment even though target dividends change continuously. In this research, I examine three other possible explanations to account for dividend stickiness: menu-costs, decision-making delays, and dividend adjustment asymmetry. The specifications in Davis and Hamilton (2004)[2] are used to test these alternative explanations. I focus on the discreteness of the dividend adjustment process. Davis and Hamilton-type models are appropriate to be applied to investigate the sticky and discrete dividend behavior for the individual stocks because target dividends change continuously whereas actual dividends change only occasionally.

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[2] Davis and Hamilton (2004) originally proposed these three explanations to test the stickiness of wholesale gasoline prices.

For the first explanation---menu-costs (i.e. a constant adjustment cost) --- I use Dixit's menu-cost model. The idea is to see if the dynamic and discrete dividend adjustment behavior can be described by this specification with a constant adjustment cost[3]. For the second explanation--- decision-making delays--- I use the Logit specification and the ACH (Autoregressive Conditional Hazard) model[4]. The Logit specification allows me to model the probability of a dividend change, and the ACH model captures the probability of a dividend change based on the past durations between changes in dividends and other explanatory variables. For the third explanation--- dividend adjustment asymmetry--- I use the Logit specification with asymmetry.

In Chapter II of my dissertation, I provide a brief review of the literature and analyze the Dixit's menu-cost model, the Logit specification, and the ACH model. In Chapter III, I test these three explanations for dividend stickiness on selected individual stocks. The empirical result shows the adjustment behavior of dividend is inconsistent with the menu-cost model of Dixit (1991). I find decision-making delays and dividend adjustment asymmetry might be possible alternative explanations for selected individual stocks.

The empirical results in Chapter III indicate the menu-cost model is not the appropriate specification in accounting for the dividend adjustment process. In Chapter IV, I use an alternative specification --- a quadratic adjustment cost model--- to examine the question of whether adjustment costs can explain the slow adjustment of dividends in

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3 Davis and Hamilton (2004) used Dixit's menu-cost model to investigate whether this specification can describe the dynamic sticky and discrete adjustment of individual wholesale gasoline prices to continuous changes in bulk spot gasoline prices.

4 ACH model proposed by Hamilton and Jorda (2002) was originally used to forecast the federal funds rate targets, which are discrete-valued time series.

the aggregate stock market. I derive a dynamic dividend adjustment process and apply a two-step methodology to estimate the structural parameters in the Euler equation. The empirical results suggest adjustment costs might be a significant factor explaining the slow dividend adjustment for S&P 500.

CHAPTER II

LITERATURE AND THE EMPIRICAL MODELS

2.1. Introduction

Corporate dividend policy is an important issue in the financial literature. Although most researchers have recognized dividend smoothing in the stock market, only a few studies have investigated the determinants of dividend smoothing. Lintner (1956) developed the partial adjustment specification to explain the sluggish adjustment of dividends. However, Lintner's model is not consistent with the discrete dividends in most stocks, since it implied that dividend adjustments are continuous with respect to the stochastic variations in target dividends[5].

Although it is known that dividends are generally rigid and discrete, few studies in financial literature analyze the dynamic models of discrete dividends; the primary reason for this being absence of the theory on the discreteness of dividends. Kumar and Lee's (2001) paper was the first to develop and empirically implement a dynamic discrete dividend model for proposing some determinants of smoothing dividends. They showed that dividend smoothing is positively associated with the factors that adversely impact of the investor's demand. These factors include risk factors: higher earnings

[5] Cyert, Kang, and Kumar (1996) found the observed dividends are discrete in most firms; they estimated the average length, which stocks remained unchanged dividends, is 6.5 quarters in the NYSE sample of 309 stocks for the period 1972-1995.

variance, lower liquidity, and higher probability of bankruptcy, as well as the lower expected return on capital investment by the firm.

The primary objective of this research is to uncover the additional determinants of sticky and discrete dividends. I accomplish this by analyzing the link between the discrete dividends and three alternative explanations. These are menu-costs, decision-making delays, and dividend adjustment asymmetry. These three explanations originally were proposed by Davis and Hamilton (2004) to test the stickiness of wholesale gasoline price. Since the adjustments of individual wholesale gasoline prices are also sticky and discrete with respect to continuous changes in bulk spot gasoline prices, Davis and Hamilton-type models seem appropriate to empirically examine the explanations of sticky and discrete dividends.

I next review the literature for the stock market. The literature examines how managers set dividends. It connects Davis and Hamilton’s specifications to the adjustment behavior of dividend.

The partial adjustment process proposed by Lintner (1956) is the first known empirical specification of corporate dividend decisions. However, it was based on a set of interviews with managers about their dividend policies. Thus, Garrett and Priestley (2000) developed Lintner’s partial adjustment equation by deriving the manager’s optimal strategy of setting dividend within a theoretical specification.

In Garrett and Priestley's specification, managers are assumed to minimize the quadratic cost function of dividend adjustment[6]. Managers are penalized for the deviations of dividends from their target levels and the deviations of dividend growth rate from a constant rate (α). An agency cost between managers and shareholders (Rozeff, 1982) is incurred by the firm whenever the actual dividend is below the target level ($d_t < d_t^*$). The agency cost is an implicit cost and arises from the conflict between managers and shareholders. Assuming that managers hold a lower fraction of the stocks than shareholders, when managers hold more retained earnings (managers pay dividends below target dividends, $d_t < d_t^*$), they may use these retained earnings to invest in projects inefficiently. Thus, the agency costs arise. The positive deviations of actual dividends from the target levels ($d_t > d_t^*$) also could make firms lose. When dividends are larger than target dividends, and assuming that external finance is costly, higher dividend payouts may cause firms to lose the opportunity of reinvesting earnings on projects paying above-market rates of return.

In Garrett and Priestley's (2000) model, managers at each period are assumed to minimize the loss resulting from the deviations of dividends from their target levels. That is, managers consider the deviation cost of $d_t - d_t^*$ when they set the dividend. Thus, the deviation between the current dividend and target level should be an important factor influencing the probability of a dividend change in the next period.

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[6] The quadratic cost function is as following,

$$C = \theta_1 (d_t - d_t^*)^2 + \theta_2 (\Delta d_t - \alpha)^2$$

where θ_1 and θ_2 are the loss weights in managers' mind, d_t is observed dividend, d_t^* is target dividend and α is one constant growth rate of dividend.

In addition, Marsh and Merton (1987) point out one of Lintner's important stylized facts (1956) in the stock market; most managers avoid making changes in dividends since the potential costs could arise if managers change the dividends. There are some sources of potential adjustment costs managers might face. For example, Garrett and Priestly (2000) mentioned a nonstable dividend policy could increase the uncertainties of managers' decisions and therefore increase the management costs. Another source, dividends might convey the information of the future stock price to investors[7]. Thus, managers are extremely reluctant to cut dividends because they are worried about sending a bad signal to investors. Further, managers are slow to increase dividends because they want to minimize the probability that they have to cut the dividends in the future. Garrett and Priestly (2000) mentioned a stable dividend policy could smooth investors' reactions. It can lower the likelihood of losing investors' confidences in the stock's future valuations.

According to the Dixit's model, the deviation $d_t - d_t^*$ and menu-costs (i.e. a constant adjustment cost) are the two most important factors influencing the probability of a dividend change in the next period. Thus, the Dixit's functional form seems reasonable for investigating the dynamic adjustment process of dividend. I next summarize why the Dixit's model is an appropriate specification of dividend payout for the individual stocks.

[7] There is a substantial literature (Michaely, Thaler, and Womack ,1995; Kao and Wu, 1994; and Healy and Palepu,1988) showing that the price of a firm's stock rises (falls) when the firm announces a dividend increase (decrease).

The Dixit's model is believed to be a proper specification to investigate the dividend adjustment process since it can satisfy four main aspects of stock market that reflect the dividend policy of observed payout strategies. Firstly, as noted earlier, in Garrett and Priestley's specification, the optimal response of managers when setting dividends is to consider the loss of dividends deviating from target levels. One of the important elements in the Dixit's model includes the difference between the dividend and target level. Secondly, the solution of Dixit's model can control the discreteness of the dividend adjustment even though target dividends change continuously. Then the specification can capture the discreteness of the dividend adjustment process. Thirdly, if dividends are smoothing, the test specification should concern the long-run horizon. The Dixit's model can solve the adjustment loss of changing dividend by setting up the minimization problem for the entire time horizon from current period to infinity. Fourthly, the adjustment costs could arise when managers change the dividends. In the Dixit's menu-cost model, the adjustment costs can be assumed to be constant when managers change the dividends. Managers strategically choose the quarters at which to change dividend so as to minimize the total adjustment loss of changing dividends.

I find in many respects, the Dixit's framework appears consistent with the features of dividend payouts for the individual stocks. That is, Dixit's model implies a particular functional form of manager's behavior on setting dividends.

This research uses Dixit's model as the starting point to investigate the patterns managers could use on deciding dividends. In Dixit's specification, the deviation $d_t - d_t^*$ helps predict a dividend change. Hence, all the other specifications (Logit specification, and ACH model), which are used to examine decision-making delays and dividend adjustment asymmetry for sticky dividends (Davis and Hamilton, 2004), also include the deviation term $d_t - d_t^*$. These specifications allow me to interpret whether these explanations are consistent with the behavior of dynamic dividend adjustments.

To test the above three explanations, I use three methods. The remainder of this chapter describes these models as follows. In section 2.2, I give a description of Dixit's menu-cost model (1991). In section 2.3, I describe the Logit model. In section 2.4, I describe the ACH model.

2.2. The Dixit menu-cost model

In the Dixit's model, managers are assumed to minimize the total loss resulting from the deviation cost of dividends from target levels and the constant adjustment cost of changing dividends. Since the adjustment costs arise when mangers change the dividend, managers choose quarters $t_1, t_2 \cdots$ in which to change dividend so as to minimize the following adjustment loss function of dividends:

$$E_{t_0}\left\{\sum_{i=1}^{\infty}\left[\left(\int_{t_{i-1}}^{t_i} e^{\beta t} k\,(d_{t_{i-1}} - d_t^*)^2\, dt + g\, e^{\beta t_i}\right]\right\} \tag{2.1}$$

with $d(t_0) = d^*(t_0)$ given

and $d\, d^*(t) = \sigma dB(t)$

Let $d_{t_{i-1}}$ denote the previous dividend determined by managers, $B(t)$ is a standard Brownian motion. σ is the standard deviation of the change in the target dividends, $d^*(t)$. β is the discount factor, and g is the lump-sum adjustment cost (called the menu cost in this model) when dividends change at quarters $t_1, t_2 \cdots$. The parameter k scales the quadratic unit cost of deviating from the target dividend d_t^*.

Since managers are assumed to wait to change a dividend in order to avoid the adjustment costs, they choose to either keep dividends unchanged or set dividends as the target levels with respect to the variations of target dividends at each period. If the target dividend evolves stochastically, then there are two points, one is below target dividend and another is above, at which managers will change the dividends. Dixit (1991) and Hansen (1999) showed the solution in Eq. (2.2), which managers change the dividend and set actual dividend equal to target dividend, $d_{t_i} = d^*(t_i)$, when $\left|d_{t_{i-1}} - d_{t_i}^*\right| = b$ happens in any quarter t_i, with the optimal maximal deviation b given by

$$b = \left(\frac{6 g \sigma^2}{k}\right)^{\frac{1}{4}} \tag{2.2}$$

From Eq. (2.2), some static comparative economic intuition in the stock market can be obtained. First, if the menu costs increase, it is more costly to adjust the dividends. Then the range of inaction widens, managers could postpone the decision on changing a dividend. Second, if k, which scales the quadratic unit cost of deviating from d_t^*, is larger, then the adjustment loss of being out of target dividend is greater and therefore, the zone becomes more narrow.

Suppose mangers determine whether to adjust the dividends by following the above policy, then the probability that the dividend changes between quarter *t* and *t+1* can be estimated by the following,

$$\text{Prob}(\left|d_t - d^*_{t+1}\right| > b) \tag{2.3}$$

Davis and Hamilton (2004) derived the probability of $\left|d_t - d^*_{t+1}\right| > b$. It is labeled $h\left[d_t, d^*_t\right]$, and can be approximated by (see Appendix)

$$h\left[d_t, d^*_t\right] = \Phi(\frac{d_t - d^*_t - b}{\sigma}) + 1 - \Phi(\frac{d_t - d^*_t + b}{\sigma}) \tag{2.4}$$

where Φ is the cumulative distribution function of a standard normal variable. In the observed discrete-time data on dividends, let $x_t = 1$ if the dividend changes in quarter *t* and zero otherwise. The log of the likelihood of observing the sample $\{x_1, x_2, ..., x_T\}$ is then given by

$$\sum_{t=0}^{T-1}\left\{x_{t+1}\log h(d_t, d^*_t) + (1 - x_{t+1})\log\left[1 - h(d_t, d^*_t)\right]\right\} \tag{2.5}$$

b, σ in Eq. (2.4) are chosen to maximize the log of the likelihood in Eq (2.5). The parameter estimates of b and σ imply an estimate of the expected time interval between changes in the dividends and can be used to judge whether this menu-cost model is an appropriate specification of the dividend process.

2.3. The Logit model

The Logit specification is used to examine the possible explanations based on a decision-making delay and on dividend adjustment asymmetry. In the Logit model, Eq. (2.6), the probability of a dividend change at *t+1*, h_{t+1}, depends on a vector of variables Z_t which are used to forecast the probability to a dividend change. Hence,

$$h_{t+1} = \frac{e^{\delta' Z_t}}{1 + e^{\delta' Z_t}} \tag{2.6}$$

where δ is the parameters multiplying Z_t.

Given this probability h_{t+1}, I can evaluate the log likelihood function. Let $x_t = 1$ if dividend changes in quarter *t* and zero otherwise. The parameter vector δ is estimated by maximizing the likelihood function given in Eq. (2.7),

$$\sum_{t=0}^{T-1} \{ x_{t+1} \log h_{t+1} + (1 - x_{t+1}) \log(1 - h_{t+1}) \} \tag{2.7}$$

2.4. The autoregressive conditional hazard model

Since dividends are generally discrete for individual stocks, the disadvantage of using the traditional Logit model is that significant serial correlation could arise. The discreteness of dividend also implies that the lagged time interval between dividend changes may be relevant for the timing of the next dividend change. Thus, I use an alternative model, the Autoregressive Conditional Hazard specification (ACH), to model the serial dependences and lagged time intervals in discrete-valued dividend series. This model was proposed by Hamilton and Jorda (2002). It can remove the serial correlation properties in the dynamics of the limited dependent dividend variable. In addition to taking account of the expected duration of dividend changes, this model also incorporates updated explanatory variables, which may help forecast the probability of a dividend change.

The ACH model was developed originally from the ACD (Autoregressive Conditional Duration) model proposed by Engle and Russell (1998). In Engle and

Russel's ACD (m, r) specification, let *n* describe the cumulative number of dividend changes, u_n denotes the length of quarters between the *nth* and *(n+1)th* time at which managers change the dividend payouts. ψ_n represents the expectation of u_n given past observations $u_{n-1}, u_{n-2} \ldots u_1$ as the following equation,

$$\psi_n = \sum_{j=1}^{m} \alpha_j u_{n-j} + \sum_{j=1}^{r} \beta_j \psi_{n-j} \tag{2.8}$$

For example, the ACD (1, 1) model forms the expectation ψ_n as the following

$$\psi_n = \alpha u_{n-1} + \beta\alpha u_{n-2} + \beta^2 \alpha u_{n-3} + \ldots + \beta^{n-2} \alpha u_1 + \beta^{n-1} \alpha \overline{u} \tag{2.9}$$

where $\overline{u}$ is the average length of quarters observed between changes in dividends. Engle and Russell (1998) denoted the probability of a divided change in quarter *t+1* as

$$h_{t+1} = \frac{1}{\psi_{n(t)}} \tag{2.10}$$

Hamilton and Jorda (2002) proposed the ACH specification that can generalize the ACD model, in which the probability of a dividend change at period *t+1* is function of linearly on expected durations $\psi_{n(t)}$ and other variables Z_t. Let $n(t)$ denote the number of times manager has been observed to change dividends of quarter *t*. Then Eq. (2.11) is one general expression of ACH model,

$$h_{t+1} = \frac{1}{\psi_{n(t)} + \xi' Z_t} \tag{2.11}$$

where h_{t+1} is the hazard rate, that is , it is the probability of a dividend change in quarter *t+1*, Z_t denotes a vector of other variables which can help predict the probability of a dividend change in quarter *t+1* and these variables are known at time *t*.

It is important to confirm that the hazard rate h_{t+1} is not outside of (0, 1). Hence, Hamilton and Jorda proposed (2002) the following function Eq. (2.13) to smooth transition such that the following hazard rate always lies in $[0,1]$,

$$h_{t+1} = \frac{1}{\lambda\left[\psi_{n(t)} + \xi' Z_t\right]} \tag{2.12}$$

The denominator in Eq. (2.12) is specified by the following,

If $\left[\psi_{n(t)} + \xi' Z_t\right] \leq 1$,

$$\text{then , } \lambda\left[\psi_{n(t)} + \xi' Z_t\right] = 1.0001$$

If $1 < \left[\psi_{n(t)} + \xi' Z_t\right] < 1 + \Delta_0$, where $\Delta_0 \equiv 0.1$

$$\text{then, } \lambda\left[\psi_{n(t)} + \xi' Z_t\right] = 1.0001 + \frac{2\,\Delta_0(\psi_{n(t)} + \xi' Z_t - 1)^2}{\Delta_0^2 + (\psi_{n(t)} + \xi' Z_t - 1)^2}$$

If $\left[\psi_{n(t)} + \xi' Z_t\right] \geq 1 + \Delta_0$, where $\Delta_0 \equiv 0.1$

$$\text{then, } \lambda\left[\psi_{n(t)} + \xi' Z_t\right] = 1.0001 + \left[\psi_{n(t)} + \xi' Z_t\right] \tag{2.13}$$

Therefore, I have one differentiable smooth function for the transition of values between 1.1 and 1.0001 for Eq. (2.12). The numerical procedure can select a value of h_{t+1} inside of (0, 1).

Given the hazard rate in Eq. (2.12), the log likelihood function is estimated. In the observed discrete-time on dividends, let $x_t = 1$ if the dividend changes in quarter t and zero otherwise. The log of the likelihood of observing the sample $\{x_1, x_2, \ldots, x_T\}$ is then given by

$$L_1(\theta_1) = \sum_{t=0}^{T-1} \left\{ x_{t+1} \log h_{t+1} + (1 - x_{t+1}) \log(1 - h_{t+1}) \right\} \tag{2.14}$$

where θ_1 is the vector of parameters to influence the probability of a dividend change in Eq (2.12). This vector of parameters is estimated by maximizing Eq. (2.14). I use the ACH model to examine if decision-making delays can explain the sluggish adjustment of dividends.

CHAPTER III

EMPIRICAL ANALYSIS ON INDIVIDUAL STOCKS: WHY ARE DIVIDENDS STICKY AND DISCRETE?

3.1. Introduction

In this chapter, I use Dixit's model as the starting point to investigate possible explanations for the observed patterns of dividends. Three alternative explanations are tested. These are menu-costs, decision-making delays, and dividend adjustment asymmetry.

The Dixit's menu-cost model is used to see if dynamic dividend adjustment can be explained in terms of menu-costs (i.e. a constant adjustment cost). In the second explanation--- decision-making delays--- I use the Logit specification and the ACH model. In the third explanation--- dividend adjustment asymmetry--- I use the Logit specification with asymmetry to investigate it.

I first describe the economic intuition behind these three explanations. The first explanation is associated with adjustment costs; the potential costs managers face when they change dividends. The adjustment costs in this chapter are assumed to be constant and invariant to the magnitude of the change in dividends. Such costs are labeled menu-costs in Dixit's model. In response to a change in the target dividend, managers either make no change in dividends or else adjust dividends to the target, thus increasing an adjustment cost. If it is costly to adjust dividends, managers might keep dividends unchanged for a substantially run of periods, before inacting a change.

A second possible explanation for dividend stickiness is a decision-making delay in dividend adjustment. This explains the discreteness of dividend adjustment. This delay might be a literal time-lag in decision-making. If managers need a length of time to process information about the stochastic target dividend, then dividend stickiness might result. This is just a decision delay and differs from the menu-cost model, in which managers are concerned with the physical cost of changing dividend.

A third possible explanation for dividend stickiness is that managers are concerned with the responses of investors. An increase in dividends may reduce the funds available to managers, and therefore remove agency costs (Crutchely and Hansen, 1989; Easterbrook, 1984). Managers are more likely to increase dividends and hence reduce the agency loss when actual dividend is less than target dividend ($d_t < d_t^*$), since higher dividends can send a good signal to investors. Managers are supposed to be relatively more reluctant to cut dividends when $d_t > d_t^*$, since they are worried about investors' confidence in the stock's future valuations. Asymmetric dividend adjustment explains dividend sluggishness since it reflects strategic considerations about investors' response to a dividend adjustment. Although this asymmetric specification is contrary to the assumption of Dixit's model, there is significant evidence for asymmetric dynamic adjustment of dividends on selected individuals stocks.

I first select six stocks to examine whether the three explanations can account for sticky and discrete dividend. I further compare the predictions of a dividend change among the Dixit's model, the alternative Logit, and the ACH specification. I hope to shed light on which of the there explanations most accurately describe the sticky and discrete dividend process for the individual stocks.

The rest of this chapter is organized as follows. In section 3.2, describes the data used in this chapter. In section 3.3, estimates the target dividends. In section 3.4, reports the empirical results for the menu-cost model. In section 3.5, uses the Logit and the ACH model to investigate the decision-making delays. In section 3.6, uses the Logit model to investigate the asymmetric dividend adjustment. In section 3.7, presents the main conclusion.

3.2. Data

The data used in this chapter are extracted from Compustat. The variables are composed of quarterly dividends, and stock prices[8]. I restrict my sample to six stocks, GE, NY Times, Duquesne Light Holdings INC (Duquesne), MEG Energy INC (MEG), Murphy Oil Corp (Murphy), and Midland Co (Midland)[9]. I investigate whether any of these three explanations listed above can account for dividend stickiness in each of these

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[8] In order to deal with stock splits, all the variables are deflated by the default cumulative adjustment factor of Compustat.

[9] Since the target dividends in managers' mind are unobservable and there has been difficulty in measuring them precisely, I select only the stocks whose parameter estimates are consistent with the menu-cost model. The empirical results for 15 other individual stocks either did not converge or did not produce reasonable estimates in the menu-cost model.(stock Exxon, Bank of NY, Bank of America, Piedmont Natural Gas Co, International Paper Co., Carpenter Technology Corp, Handleman Co., Genuine Part Co., Air Products & Chemical INC., INTL Business Machine Corp, Motorola INC, CMS Energy Corp, PG&E Corp, General Mills INC, Dow Chemical)

stocks. Figure 3.1 plots the dividends and stock prices of these six stocks. It is found that the dividends are rigid and discrete.

3.3. Estimating the target dividend series

To complete this analysis, my first step is to estimate the target dividends. Previous studies including Marsh and Merton (1987), Kao and Wu (1994), Kumar and Lee (2001) specified target dividends as proportion to the permanent earnings as in Eq. (3.1).

$$d_t^* = rY_t^P \tag{3.1}$$

Here d_t^* is the target dividend and defined as a percentage r of permanent earnings, Y_t^P. Lintner called r the long run target payout ratio, and suggested the ratio is constant; $0 \le r < 1$.

Marsh and Merton (1987) employed the stock price as a measure of permanent earnings. Thus, I follow Marsh and Merton (1987) and assume stock price is a proxy for a stock's permanent earnings.

The long run target payout ratio, r, is estimated as the constant average markup of dividends over the permanent earnings[10]. That is,

$$\hat{r} = \frac{1}{T}\sum_{i=1}^{T}\frac{d_t}{p_t} \tag{3.2}$$

where T is the number of quarters over the samples in each stock.

[10] Kumar and Lee (2001) also used the same method to estimate the long-run target payout ratio.

The estimates of $\hat{r}$ are reported in the first row of Table 3.1. Then, the target dividends are estimated by Eq. (3.3),

$$\hat{d}_t^* = \hat{r} P_t \tag{3.3}$$

For a preliminary analysis of dividend payouts, Figures 3.2 plots the dividends with corresponding target dividends estimated by Eq. (3.3). Figures 3.3 plots the deviation between the actual and target dividends, $d_t - d_t^*$.

Target dividends are assumed to follow a random walk in the Dixit's menu-cost model. Hence, the Augmented Dickey-Fuller test without lagged terms, Eq. (3.4), is used to examine.

$$\Delta \hat{d}_t^* = \varsigma \hat{d}_{t-1}^* + \varepsilon_t \tag{3.4}$$

Eq. (3.4) is employed to test the null hypothesis of $\varsigma = 0$. As shown in Table 3.2, for all the stocks, the null hypothesis cannot be rejected at the 5% level of significance. Hence, the results show target dividends I estimated by Eq. (3.3) are consistent with the assumption of the Dixit's menu-cost model in which target dividends are assumed to follow a random walk.

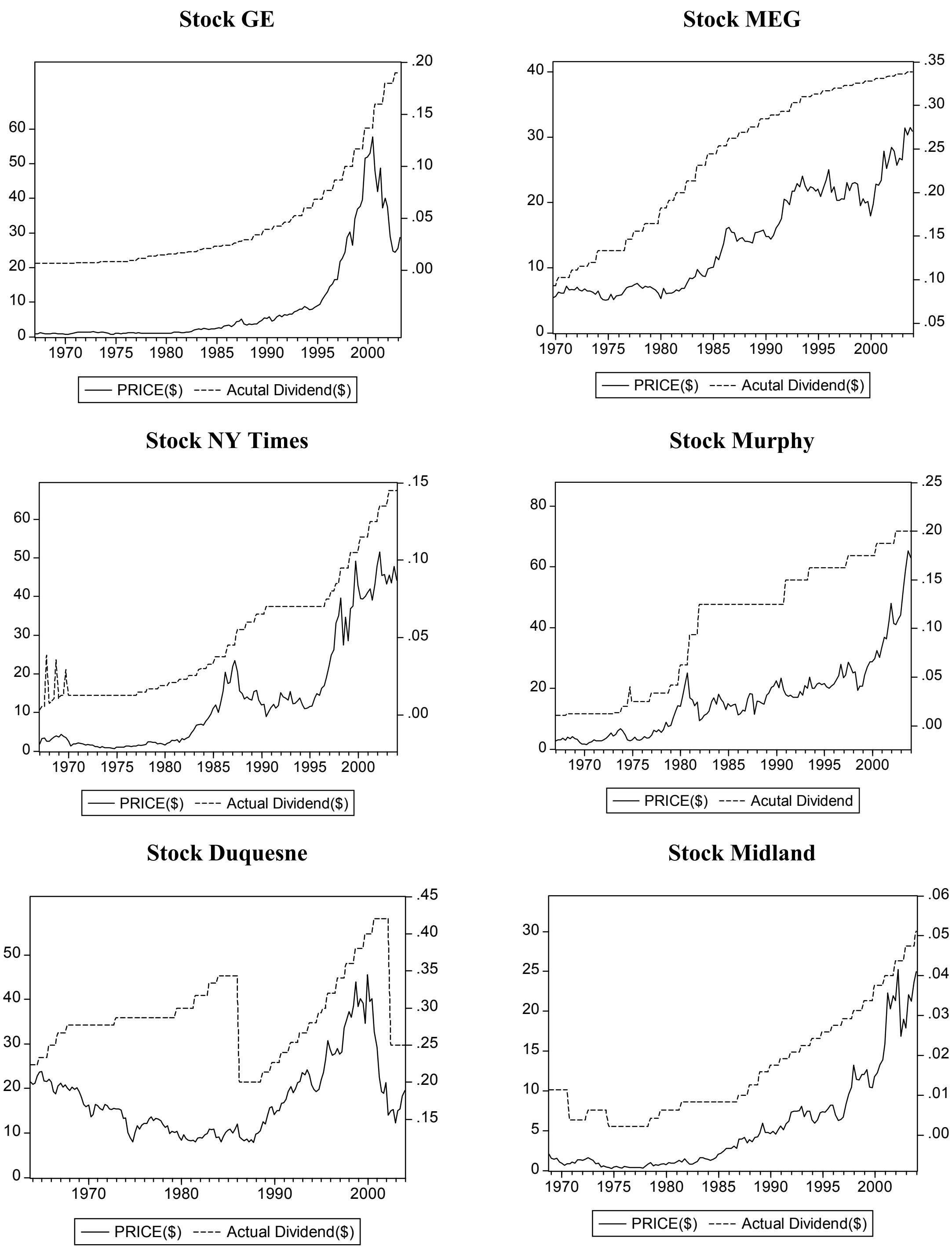

Fig. 3.1. Stock price and actual dividend

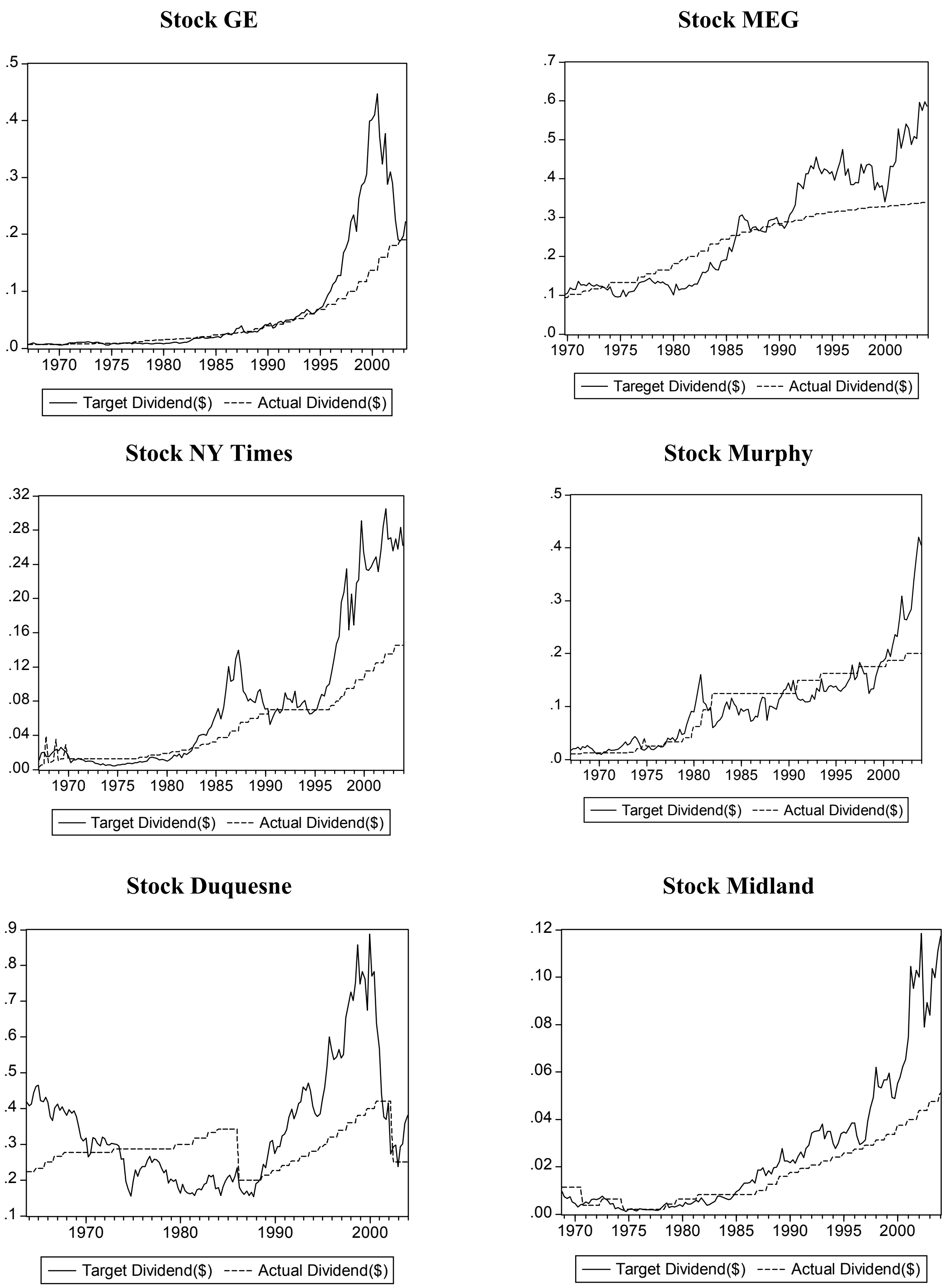

Fig. 3.2. Target dividend and actual dividend

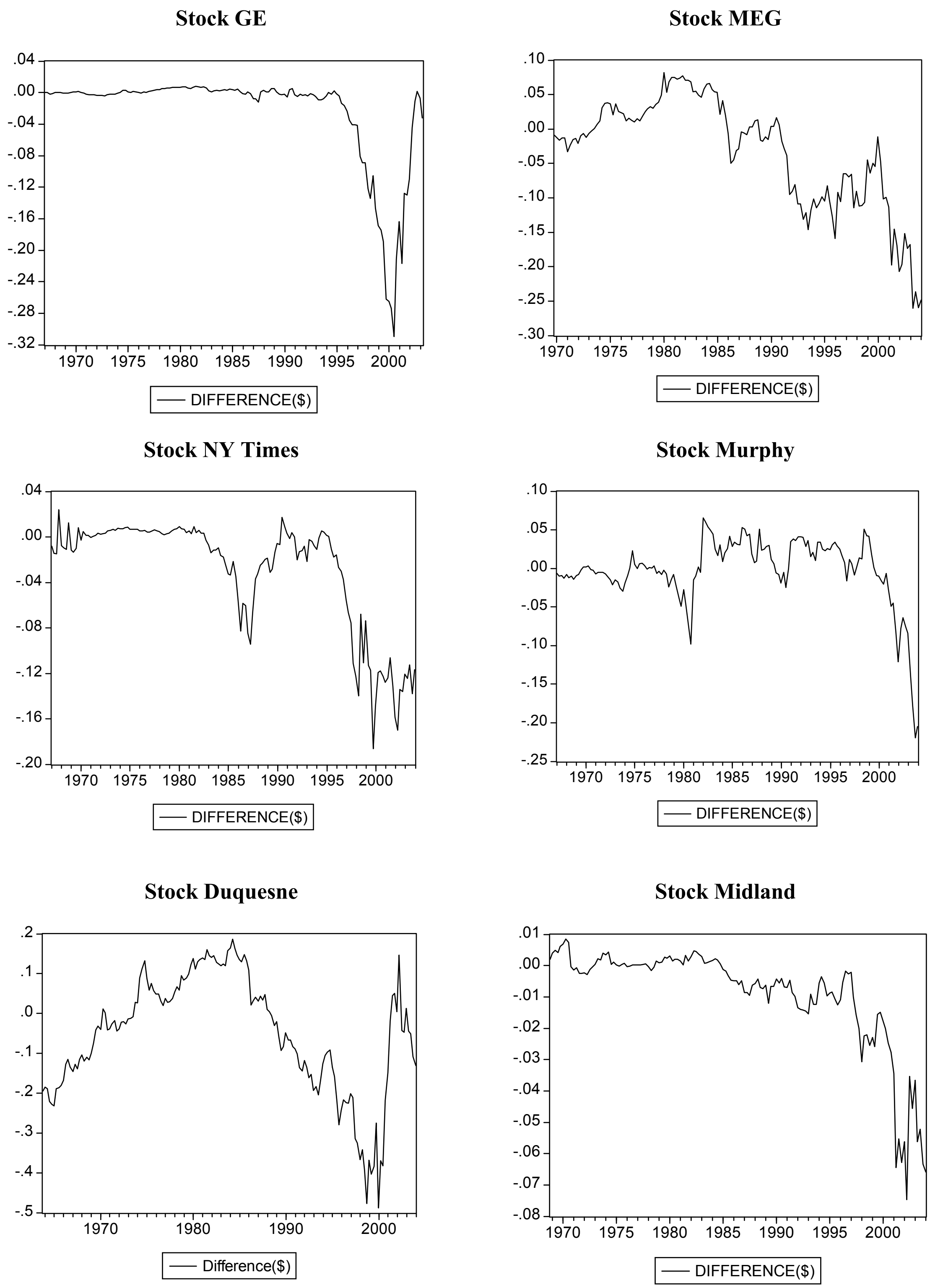

Fig. 3.3. The difference between actual dividend and target dividend

Table 3.1
Menu-cost model estimation

Stock	GE	NY Times	Duquesne	MEG	Murphy	Midland
$\hat{r}$	0.00858	0.00592	0.01950	0.01901	0.00643	0.00470
b_{MLE}	0.4690***	0.1371***	0.2805***	0.2256***	0.0772***	0.0086
	(0.0575)	(0.0288)	(0.0219)	(0.0651)	(0.0058)	(0.0575)
σ_{MLE}	0.3067***	0.0920***	0.1202***	0.1726***	0.0273***	0.0043
	(0.0348)	(0.0199)	(0.0121)	(0.0523)	(0.0020)	(0.0348)
σ_{direct}	0.0176	0.0148	0.0403	0.0220	0.0153	0.0057
b_{direct}	0.0233	0.0050	0.0133	0.0044	0.0125	0.0021
$\frac{b^2_{MLE}}{\sigma^2_{MLE}}$	2.3377	2.2186	5.4402	1.7085	7.9749	4.0012
log L	-76.7392	-79.9871	-70.3930	-79.1529	-48.3683	-64.1263
Obs	146	149	162	138	149	142

Notes: Asymptotic Standard errors are in the parentheses. Asterisk (*) denotes statistically significant at the 10% level. Double-asterisk (**) denotes statistically significant at the 5% level. Tri-asterisk (***) denotes statistically significant at the 1% level.

Table 3.2
Random walk test on target dividends

Stock	Lag Order	ADF t-statistic	Critical Value
GE	0	0.077416	-1.943042
NY Times	0	0.862802	-1.942996
Duquesne	0	-0.744392	-1.942818
MEG	0	1.687259	-1.943175
Murphy	0	2.678637	-1.942996
Midland	0	1.765368	-1.943107

Note: Critical values are at 5% significance level.

3.4. Empirical results for the menu-cost model

I first use the Dixit's menu-cost model to forecast the quarters in which a manager would change his dividend payout. The Dixit's model is summarized as following,

$$E_{t_0}\left\{\sum_{i=1}^{\infty}\left[\left(\int_{t_{i-1}}^{t_i} e^{\beta t} k\,(d_{t_{i-1}} - d_t^*)^2\, dt + g\, e^{\beta t_i}\right]\right\} \tag{3.5}$$

with $d(t_0) = d^*(t_0)$ given

and $d\,d^*(t) = \sigma dB(t)$

Managers change the dividend and set actual dividend equal to target dividend, $d(t_i) = d^*(t_i)$, when $\left|d_{t_{i-1}} - d_{t_i}^*\right| = b$ happens in any quarter t_i (by the solution of Dixit 1991; Hansen, 1999). Davis and Hamilton (2004) derived the probability of a dividend change between quarter *t* and *t+1* as $h[d_t, d_t^*]$,

$$h[d_t, d_t^*] = \Phi\left(\frac{d_t - d_t^* - b}{\sigma}\right) + 1 - \Phi\left(\frac{d_t - d_t^* + b}{\sigma}\right) \tag{3.6}$$

where d_t denotes the actual dividend payout, and d_t^* as the target dividend, Φ is the cumulative distribution function of a standard normal variable. σ is the standard deviation of the change in the target dividends, b is the optimal maximal deviation between actual and target dividend.

Let $\Delta_t \equiv d_t - d_t^*$ be the gap between dividend and target level, and $\bar{\Delta} \equiv T^{-1}\sum_{t=1}^{T}\Delta_t$ is the average markup for each stock. I replaced $d_t - d_t^*$ in Eq (3.6) with $\Delta_t - \bar{\Delta}$, the value of the deviation of the actual dividend from the target level. In Eq. (3.7), let $x_t = 1$ if the dividend changes in quarter t and zero otherwise. I choose b and σ in Eq (3.6) so as to maximize the following Eq. (3.7)

$$\sum_{t=0}^{T-1}\left\{x_{t+1}\log h(d_t,d_t^*)+(1-x_{t+1})\log\left[1-h(d_t,d_t^*)\right]\right\} \qquad (3.7)$$

Table 3.1 shows the results of the menu-cost model estimation for six stocks. The maximum likelihood estimates of b and σ are reported in the second and third rows in Table 3.1. The b estimates range between 0.0086---0.4690 among the six stocks. The σ values, the standard deviation of change in the target dividends, vary between 0.0043---0.3067 per quarter. The empirical results imply that the structure interpretation of the estimated coefficients is not so consistent with the dividend data, since these estimated values b, σ seem too large. Hence I examine the plausibility of the estimated value of b and σ.

In order to examine the plausibility of the estimated parameter, b_{MLE}, I directly estimate b_{direct} by finding the median absolute value of the change in dividend for those quarters when managers adjust their dividends. The results are reported in the fifth row of Table 3.1. I also directly estimate the parameter σ, which corresponds to the standard deviation of changes in d_t^*. The direct estimator σ_{direct} can be inferred by the standard deviation of $d_t^*-d_{t-1}^*$ and are reported in the fourth row of Table 3.1.

These σ_{MLE} estimated by menu-cost model are larger than those values of σ_{direct} in five of the six stocks. This might be a problematic result for the suitability of the menu-cost model. I interpret that this problem comes from the difficulty in forecasting the target dividends. Since target dividends are unobservable, stock prices are used as the proxies of estimating target dividends. However, stock prices are relatively more volatile than actual dividends. In other words, the estimated target dividend $\hat{d}_t^*$ could fluctuate more than true target dividend d_t^*. If the proxy of managers' target dividends, $\hat{d}_t^*$, differs from the true target dividends d_t^* ($\hat{d}_t^* = d_t^* + u_t$, u_t is the measurement error), this might account for an overly large estimated value for σ_{MLE}.

Another issue on the plausibility of the parameter b, the b_{MLE} estimated by menu-cost model are also significantly larger than those b calculated by median absolute value of change in dividends in all the six stocks. In order to fit the observed infrequency of dividend changes, Davis and Hamilton (2004) needed to assume that both the uncertainty about future target dividends (σ) and the amount by which it changes the dividend (b) are quite large in the Dixit's model. If this model imputes much more uncertainty about the target dividends than is warranted by the data, then it might account for much larger dividend changes than the managers actually make. σ_{direct} and b_{direct} can be inferred directly from the data other than the frequency of dividend adjustment, Davis and Hamilton (2004) concluded these inferred values are an order of magnitude smaller than the structure estimates σ_{MLE} and b_{MLE}.

However, I find that the ratios $\frac{b^2_{MLE}}{\sigma^2_{MLE}}$ are acceptable numbers given a menu-cost interpretation of setting dividend, although the level of b_{MLE} is much lager than can be reconciled with the observed magnitude of dividend changes, and the level of σ_{MLE} is also much larger than can be reconciled with the difficulty in estimating the true target dividends[11]. These ratios are reported in the sixth row of Table 3.1. The value of $\frac{b^2_{MLE}}{\sigma^2_{MLE}}$ implies an estimate of the expected time interval between changes in the dividends and can be used to judge whether this menu-cost model is an appropriate specification of the dividend process.

Managers want to find the optimal boundary at which a dividend changes so as to minimize the total loss in Eq. (3.5). Hansen(1999) solved $E\left[T \mid d(0) - d^*(0) = 0\right]$, the expected length of a cycle which is defined as the time interval until resetting the dividend as the following,

$$E\left[T \mid d(0) - d^*(0) = 0\right] = \frac{b^2}{\sigma^2} \tag{3.8}$$

Hence, the parameter estimates of b and σ imply an estimate of the expected time interval of changing dividend. It is also a measure of the expected frequency of changing dividend. From the results of menu-cost model estimation in Table 3.1, the $\frac{b^2_{MLE}}{\sigma^2_{MLE}}$ values are below 2 quarters in one of six stocks, between 2 and 2.5 quarters in two stocks, and the value of $\frac{b^2_{MLE}}{\sigma^2_{MLE}}$ for Murphy is 7.9749, for Midland is 4.0012, and for Duquesne is 5.4402. I also estimate directly the average time intervals between changes in the dividends from the data for each stock. Table 3.3 shows the direct average duration in terms of quarter, $\overline{u}_{direct}$ and the difference from the estimated length of a

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[11] Davis and Hamilton (2004) found that the parameter estimates imply a ratio of $\frac{b}{6\sigma^2}$ that is reasonable given a menu-cost interpretation of pricing gasoline, although both estimated levels of b and σ are much larger than the direct estimators of b and σ.

cycle $\frac{b^2_{MLE}}{\sigma^2_{MLE}}$. I find the direct average duration, $\overline{u}_{direct}$, is larger than the estimated expected time interval of one cycle, $\frac{b^2_{MLE}}{\sigma^2_{MLE}}$, in all six stocks. The difference is larger than 1.5 quarters in five stocks. I interpret that although managers face the adjustment cost, g when they reset the dividend, it still leads to non-rigid dividend changes. That result implies that menu-cost model cannot describe the sluggish adjustment process of dividends properly.

Table 3.3:
The average duration between changes of the dividends

Stock	GE	NY Times	Duquesne	MEG	Murphy	Midland
$\overline{u}_{direct}$	4.0968	4.000	6.2000	3.8000	9.8571	5.7826
difference	1.7591	1.7814	0.7598	2.0915	1.8822	1.7814

Notes: $\overline{u}_{direct}$ is the average time interval directly estimated between changes in the dividend.
The difference is defined as $\overline{u}_{direct} - \frac{b^2_{MLE}}{\sigma^2_{MLE}}$.

Although adjustment cost of changing dividends is probably an important factor in account for sticky dividends, the Dixit's model appears to be inconsistent with the dividend data. Possible explanations for the inconsistency are: (1) The target dividends estimated by stock prices seem more volatile than the true target dividends. That causes the inconsistency between dividend adjustments and the structure interpretation of the estimated coefficients in the Dixit's model. (2) Managers take the adjustment costs of changing dividends into account on deciding a dividend change. However, the adjustment costs might not be constant. They could be positively related with the magnitude of deviation between changes in the dividends. (3) From the implication of agency cost issues with respect to dividend policy, dividend adjustment could be symmetric. However, the asymmetric dividend adjustments in the stock market arise due to the dividend signal issues. The dividend data cannot be completely consistent with the symmetric adjustment policy of the Dixit's solution. Thus, these above reasons could cause that Dixit's model cannot describe the dividend adjustment process properly.

To analyze dynamic dividend adjustment statistically, I use two other theoretical models, which can handle the dynamics of discrete changes of dividends. One is Logit specification; another is ACH model that takes the duration between changes in the dividends into account. I next compare the performances among these three models.

Comparison results among models

I first compare the menu-cost model with the Logit specification. As in the Dixit's model, the difference between actual and target dividend is an important element influencing the probability of a dividend change. Hence, I first consider a Logit model in which the probability of a dividend change depends on the same variable $d_t - d_t^*$ as in the Dixit's model. Moreover, $d_t - d_t^*$ is taken the absolute values in Eq. (3.9), since the dividend change is assumed to be symmetric as in menu-cost model, in which optimal boundary is symmetric.

Thus, this specification in the Logit model I have:

$$Z_t = \left(1, \left|d_t - d_t^*\right|\right)' \tag{3.9}$$

Table 3.4 presents the results of the Logit model estimation [with Eq (3.9)] for the six stocks. If the coefficient of the absolute value of the difference is positive, that means once the actual dividend gets far away from the target dividend, managers might more likely to adjust the dividends. The results show that the gap is positively correlated with the probability of a dividend change in five of six stocks, although the test values are not statically significant.

The values of the log likelihood function with the Logit model are compared with those for the Dixit's menu-cost model [Eq. (3.6) and Eq. (3.7)] and are reported in Table 3.5. I find the values of the log likelihood are quite close, but the results show that the Dixit's model seems to perform better at describing the dividend data than the Logit specification.

Table 3.4
The Logit estimation

Stock	GE	NY Times	Duquesne	MEG	Murphy	Midland
Cons	-1.295***	-1.240***	-2.073***	-1.037***	-2.351***	-1.714***
	(0.2595)	(0.3193)	(0.3838)	(0.3838)	(0.3714)	(0.3045)
Z_t	0.6176	0.5692	3.2423	-0.0679	6.0766	10.7763
	(4.0089)	(6.5593)	(2.3148)	(2.3148)	(8.8411)	(17.3866)
log L	-76.7650	-80.0206	-70.4114	-79.2069	-48.4413	-64.3322
Obs	146	149	162	138	149	142

Note: Asymptotic Standard errors are in the parentheses. Asterisk (*) denote statistically significant at the 10% level. Double-asterisk (**) denotes statistically significant at the 5% level. Tri-asterisk (***) denotes statistically significant at the 1% level.

Table 3.5
Log likelihood value for menu-cost and Logit model

Stock	Menu Cost	Logit
GE	-76.7392*	-76.7650
NY Times	-79.9871*	-80.0206
Duquesne	-70.3930*	-70.4114
MEG	-79.1529*	-79.2096
Murphy	-48.3683*	-48.4413
Midland	-64.1263*	64.3322

Note: Asterisk (*) denotes the better model based on Log likelihood value. The comparison results are consistent with the results if I look at the Bayesian criterion (SBC) suggested by Schwarz(1978).

I next compare the performance of the ACH model, the Logit and the Dixit's model. To maintain the consistency within a two-parameter model on the comparison to the Dixt and Logit specification, I estimate the ACH (1, 0) model with $Z_t = 1$. That is, I solve Eq. (2.8) for $m = 1$, $r = 0$; I only take the most recent duration of dividend change into account. This condition is substituted into Eq. (2.12). The hazard rate with $Z_t = 1$ can be written as,

$$h_{t+1} = \frac{1}{\lambda[\alpha\, u_{n(t)-1} + 1]} \tag{3.10}$$

where α denotes one parameter for translating the previous duration between changes in the dividends and a hazard rate. That is, the probability of a dividend change in quarter *t+1*, h_{t+1}, depends linearly on the most recent lagged duration $u_{n(t)-1}$ and $Z_t = 1$.

The result of ACH (1, 0) model with $Z_t = 1$ [Eq (3.10)] is reported in Table 3.6. α is allowed to be negative for obtaining the convergence in the ACH model, indicating negative serial correlation. In Table 3.6, α shows negative numbers in three stocks (stock NY Times, MEG and Murphy). That is, if a manager adjusts the dividend payout in the previous quarter, then the probability of changing dividend in this current period is a little less.

Table 3.7 reports the comparison results among these three models, I find the ACH (1, 0) model is the best specification for three of these six stocks. The menu-cost model is also the best for three of six stocks. The Logit specification does not out perform the other two specifications. The overall results suggest adjustment costs and the durations between changes in the dividends could help describe the observed dividend process.

Table 3.6
ACH(1, 0) estimation (with $Z_t = 1$)

Stock	GE	NY Times	Duquesne	MEG	Murphy	Midland
Cons	1.3791	3.5820***	2.0921	2.9957	9.1402***	-1.2468
	(1.6991)	(0.8132)	(2.0276)	(2.0286)	(3.9863)	(4.3103)
α	0.5369	-0.0456	0.4940	-0.0427	-0.0207	1.1712
	(0.4549)	(0.0867)	(0.4003)	(0.5067)	(0.3075)	(0.9520)
log L	-76.0954	-79.9342	-69.5284	-79.2025	-48.6543	-63.4774
Obs	146	149	162	138	149	142

Note: Asymptotic Standard errors are in the parentheses. Asterisk (*) denote statistically significant at the 10% level. Double-asterisk (**) denotes statistically significant at the 5% level. Tri-asterisk (***) denotes statistically significant at the 1% level.

Table 3.7
Log likelihood value for alternative models

Stock	Menu Cost	Logit	ACH
GE	-76.7392	-76.7650	-76.0954*
NY Times	-79.9871	-80.0206	-79.9342*
Duquesne	-70.3930	-70.4114	-69.5284*
MEG	-79.1529*	-79.2096	-79.2025
Murphy	-48.3683*	-48.4413	-48.6543
Midland	-64.1263*	64.3322	-63.4774

Note: Asterisk(*) denotes the best model based on Log likelihood value. The comparison results are consistent with the results if I look at the Bayesian criterion (SBC) suggested by Schwarz(1978).

3.5. Empirical results for the decision-making delays

Decision-making delays arise when managers need a length of time to determine the dividend change in response to an observed gap between the actual and target dividend. For instance, the stochastic structure of target dividend may lead to managers needing more time decide the dividend payout. In such a case, the former quarters' gap may contain additional predictive power for a dividend change. This differs from the menu-cost model, in which the current quarter's gap $|d_t - d_t^*|$ is the only factor influencing the probability of a dividend change at quarter *t+1*.

The Logit specification and the ACH model offer a convenient framework for investigating the role of additional explanatory variables. Subsequently, I now outline the use both models to investigate the other explanatory variables besides $|d_t - d_t^*|$ as factors that might influence the decision to a dividend change.

If there are delays in manager's ability to process information, the former quarter's gap between dividend and target level can predict the probability of a dividend change in quarter *t+1*. Dividend adjustments are determined quarterly, and there are four quarters in a year. Thus, I examine the relation between decision delays at period $t-1$, $t-2$ and the probability of a dividend change at *t+1*. The former gaps, $|d_{t-i} - d_{t-i}^*|$ $i = 1,2$ are added into Z_t in the Logit and the ACH (1, 1) model[12] for examining the

[12] The ACH (1, 1) model is specified as the following
$h_{t+1} = \dfrac{1}{\lambda[\psi_{n(t)} + \xi' Z_t]}$, where $\psi_{n(t)} = \alpha\, u_{n(t)-1} + \beta \psi_{n(t)-1}$

explanatory power of a dividend change. I test if a prior quarter's gap, $\left|d_{t-i}-d_{t-i}^{*}\right|$, is a better predictor of the probability of a dividend change at *t+1*.

If the previous quarter's gap $\left|d_{t-1}-d_{t-1}^{*}\right|$ is tested for decision delays, the model is estimated using:

$$Z_t = \left(1,\left|d_t-d_t^{*}\right|,\left|d_{t-1}-d_{t-1}^{*}\right|\right)' \tag{3.11}$$

If the former quarter's gap $\left|d_{t-2}-d_{t-2}^{*}\right|$ is tested whether it contains additional predictive power, $\left|d_{t-2}-d_{t-2}^{*}\right|$ is added as a fourth explanatory variable in Eq. (3.11). The P-value for a likelihood test of the null hypothesis in the Logit specification, the coefficient of $\left|d_{t-i}-d_{t-i}^{*}\right|$ $i=1,2$ is zero, is reported in the Table 3.8. This test finds the evidence of decision delays for four of the six stocks.

I repeat to test the hypothesis by using the ACH (1, 1) model of Eq. (3.11). Table 3.9 shows the P-value for a likelihood test of the null hypothesis, which the coefficient of $\left|d_{t-i}-d_{t-i}^{*}\right|$ $i=1,2$ is zero. There is significant evidence of decision delays for three of the six stocks in the ACH (1, 1) specification.

Taking the results Table 3.8 and Table 3.9 together, I conclude there are delays in managers' ability to process the decisions on dividend payouts. That is, managers' processing delays could account for the stickiness of dividends on some selected stocks.

Table 3.8
Tests for significance of decision delay in Logit specification

Stock	$\{\lvert d_{t-1} - d^*_{t-1}\rvert\}$	$\{\lvert d_{t-2} - d^*_{t-2}\rvert\}$
GE	0.387	0.767
NY Times	0.892	0.001***
Duquesne	0.024**	0.225
MEG	0.716	0.932
Murphy	0.078*	0.314
Midland	0.366	0.029**

Notes: Table reports P-value. Asterisk (*) denotes statistically significant at the 10% level, Double asterisk (**) denotes statistically significant at the 5% level, Triple-asterisk (***) denotes statistically significant at the 1% level.

Table 3.9
Tests for significance of decision delay in ACH (1, 1) model

Stock	$\{\lvert d_{t-1} - d^*_{t-1}\rvert\}$	$\{\lvert d_{t-2} - d^*_{t-2}\rvert\}$
GE	0.439	0.182
NY Times	0.937	0.000***
Duquesne	0.134	0.128
MEG	0.113	0.132
Murphy	0.199	0.085*
Midland	0.618	0.006***

Notes: Table reports P-value. Asterisk (*) denotes statistically significant at the 10% level, Double asterisk (**) denotes statistically significant at the 5% level, Triple-asterisk (***) denotes statistically significant at the 1% level.

The second variable, which is added into Z_t in the Logit specification and the ACH (1, 1) model to examine the explanatory power of a dividend change, is the difference between the actual and target dividend at last change. To keep dividend smoothing in the long run, managers might deliberately stretch out dividend changes. Hence, I investigate whether managers engage in partial adjustment of dividends at quarter $\phi l(t)$. I let $\phi l(t)$ be the quarter of the stock's most recent dividend change as of quarter *t*. For example, if mangers changed the dividend in quarter $t-i$ and kept dividends unchanged from $t-i+1$ to *t*, then $\phi l(t) = t-i$. If managers changed the dividend in quarter t, then $\phi l(t) = t$. If managers adjust the dividends partially in quarter

$\phi l(t)$, then the gap, $\left|d_{\phi l(t)} - d^*_{\phi l(t)}\right|$, should help predict a dividend change in quarter *t+1* over the value of the current gap $\left|d_t - d^*_t\right|$. To test this hypothesis, I estimate the model using

$$Z_t = \left(1, \left|d_t - d^*_t\right|, \left|d_{\phi l(t)} - d^*_{\phi l(t)}\right|\right)' \qquad (3.12)$$

Table 3.10 reports the results of Logit estimation in Eq. (3.12). I find that none of the six stocks indicates the significant evidence of gradual dividend adjustment. The ACH (1, 1) model with Eq. (3.12) is also estimated. In Table 3.11, I find that $\left|d_{\phi l(t)} - d^*_{\phi l(t)}\right|$ helps predict a dividend change significantly for two of the six stocks. That is, the size of the gap remaining after the previous correction $\left|d_{\phi l(t)} - d^*_{\phi l(t)}\right|$ can help to predict a dividend change over and above the value of the current gap $\left|d_t - d^*_t\right|$. It implies that some managers deliberately stretch out dividend changes so as to keep dividend smoothing in ACH (1, 1) model.

Taking the results Tables 3.8 and 3.10 (or Tables 3.9 and 3.11) together, the former quarters' gaps, $\left|d_{t-i} - d^*_{t-i}\right| \quad i = 1,2$ or $\left|d_{\phi l(t)} - d^*_{\phi l(t)}\right|$, contains the additional predictive power on a dividend change in the next period. These results seem to imply that observed dividend adjustments are not consistent with the assumption of Dixit's model, which the probability of a dividend change at $t+1$ only depends on the value of $\left|d_t - d^*_t\right|$.

Table 3.10
Tests for significance of gradual dividend adjustment in Logit specification

Stock	$\left\{\left\|d_{\phi 1(t)} - d^*_{\phi 1(t)}\right\|\right\}$
GE	0.228
NY Times	0.192
Duquesne	0.817
MEG	0.955
Murphy	0.152
Midland	0.566

Notes: Table reports P-value. Asterisk (*) denotes statistically significant at the 10% level, Double-asterisk (**) denotes statistically significant at the 5% level, Triple-asterisk (***) denotes statistically significant at the 1% level.

Table 3.11
Tests for significance of gradual dividend adjustment in ACH(1,1) model

Stock	$\left\{\left\|d_{\phi 1(t)} - d^*_{\phi 1(t)}\right\|\right\}$
GE	0.119
NY Times	0.045**
Duquesne	0.293
MEG	0.175
Murphy	0.002***
Midland	0.373

Notes: Table reports P-value. Asterisk (*) denotes statistically significant at the 10% level, Double-asterisk (**) denotes statistically significant at the 5% level, Triple-asterisk (***) denotes statistically significant at the 1% level.

3.6. Empirical results for the dividend adjustment asymmetry

As analyzed earlier, both the Dixit's model and Logit (or ACH) specification (used to examine decision-making delays) assume that dividend adjustments are symmetric. An alternative way to distinguish adjustment costs, decision-making delays from the concern on the response of investors is to look at the evidence of asymmetric dividend adjustment. It is commonly believed that managers are more willing to increase the dividend in response to a rise in target dividends, but either are slow to react dividends or do not fully change dividends in response to a decrease in target dividends. Thus, the third explanation I investigate is whether the dividend adjustments are asymmetric with respect to the variations of dividend gaps. If so, the probability of a dividend change can exhibit an asymmetric response to the positive and negative gaps between actual dividends and target dividends. It can be inferred to make the probability of adjusting dividends higher to the negative gap ($d_t < d_t^*$) than the probability of adjusting to the positive gap ($d_t > d_t^*$). This asymmetric response occurs because of manager's strategic considerations. I use the Logit specification to examine the possible asymmetric adjustment of dividends.

There are four explanatory variables that are used to examine the asymmetric responses to a dividend change; the Logit model is estimated using

$$Z_t = \left[\Psi_t, \Psi_t(d_t - d_t^*), (1-\Psi_t), -(1-\Psi_t)(d_t - d_t^*)\right]' \tag{3.13}$$

Let $\Lambda_t = \log(\frac{d_t}{d_t^*})$ the percentage gap, and $\overline{\Lambda} = T^{-1}\sum_{t=1}^{T}\Lambda_t$, the average percentage markup. I replaced d_t - d_t^* in Eq. (3.13) with $\Lambda_t - \bar{\Lambda}$, the value of the deviation between the log of actual and the log of target dividends payout at time t. Figure 3.4 plots the percentage gap. Ψ_t is a dummy variable, Ψ_t is the value of 1 if $\Lambda_t - \bar{\Lambda} > 0$ and 0 otherwise. I investigate the effect of the sign of the dividend gap on the probability of a dividend change in any given quarter. The parameters in Eq. (3.14) are estimated by maximizing the likelihood function and are reported in Table 3.12.

$$Z_t = \left[\Psi_t, \Psi_t(\Lambda_t - \bar{\Lambda}), (1-\Psi_t), -(1-\Psi_t)(\Lambda_t - \bar{\Lambda})\right]' \tag{3.14}$$

For five of the six stocks, the coefficient $1-\Psi_t$ in Eq. (3.14) is larger than the coefficient on Ψ_t which means that mangers are more likely to increase the dividend payout when $\Lambda_t - \bar{\Lambda} = -\varepsilon$ than it is to change the dividend when $\Lambda_t - \bar{\Lambda} = \varepsilon$ for ε a small positive number. A second source of asymmetry is that the coefficient of $-(1-\Psi_t)(\Lambda_t - \bar{\Lambda})$ is also bigger than the coefficient of $\Psi_t(\Lambda_t - \bar{\Lambda})$ in five of six stocks. This implies managers are more likely to increase the dividends when $\Lambda_t - \bar{\Lambda} = -\varepsilon$ than to change the dividends when $\Lambda_t - \bar{\Lambda} = \varepsilon$ for ε a large positive number. That is, for big changes, managers are more likely to increase dividends on the negative deviation gaps than to change dividends on the positive gaps; for small changes, managers are also more likely to increase dividends on the negative deviation gaps than to change dividends on the positive gaps.

Table 3.12
Asymmetric Logit estimates

Stock	GE	NY Times	Duquesne	MEG	Murphy	Midland
Pos Const	-1.404***	-2.081***	-2.129 ***	-1.315***	-3.291***	-3.126***
	(0.3851)	(0.6330)	(0.6748)	(0.5273)	(0.9538)	(0.8845)
Pos gap	0.431	1.053	0.640	0.214	1.982	3.131
	(2.6204)	(2.4116)	(3.3816)	(4.1386)	(6.5078)	(2.8332)
Neg Const	-1.195**	-1.741***	-2.576 ***	-0.861***	-2.088***	-1.915**
	(0.4853)	(0.5479)	(0.6931)	(0.4286)	(0.6285)	(0.5584)
Neg gap	0.315	4.663	7.380**	0.231	3.341	4.691
	(2.3300)	(2.1955)	(3.6396)	(3.8650)	(2.7663)	(3.0569)
Log L	-76.6161	-73.7813	-68.0589	-78.5401	-44.1340	-59.8268
Obs	146	149	162	138	149	142

Note 1: Asymptotic Standard errors are in the parentheses.
Asterisk (*) denotes statistically significant at the 10% level, Double-asterisk(**) denotes statistically significant at the 5% level, Triple-asterisk(***) denotes statistically significant at the 1% level.

Note 2: The coefficient of Pos Const is Ψ_t , the coefficient of Pos gap is $\Psi_t(\Lambda_t - \bar{\Lambda})$, the coefficient of Neg Const is $1-\Psi_t$, the one of Neg gap is $-(1-\Psi_t)(\Lambda_t - \bar{\Lambda})$.

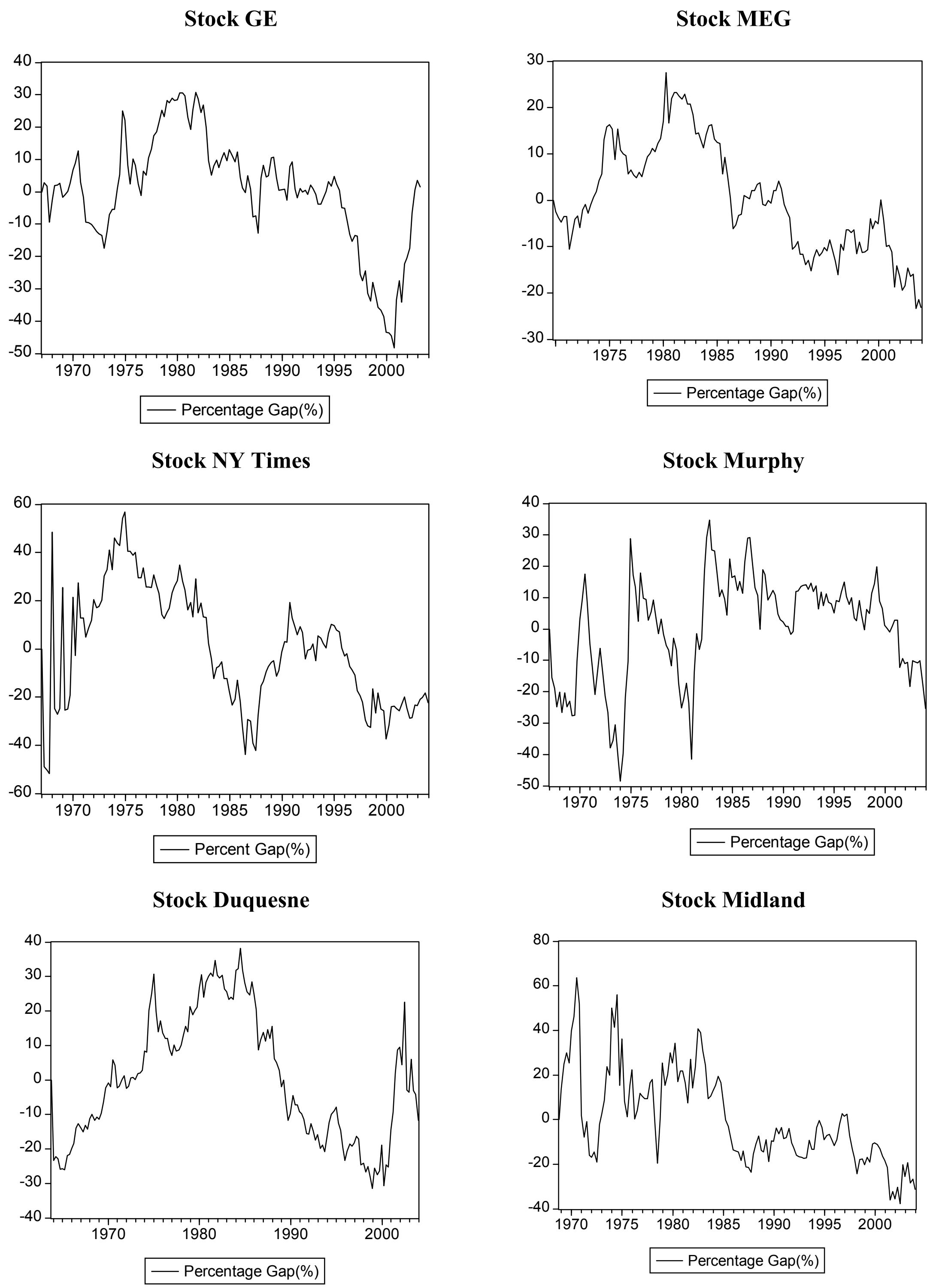

Fig. 3.4. The gap percentage between actual dividend and target dividend

Figure 3.5 plots the asymmetry of dividend changes in the Logit specification Eq. (2.6) for Z_t given by Eq. (3.14) as a function of $\Lambda_t - \bar{\Lambda}$ for each stock. It indicates the probability that managers change their dividends in quarter *t+1* when the gap percentage between actual dividends d_t and target dividends d_t^* vary from –25 to 25 percentages.

To examine the possibility of an asymmetric response of dividend adjustment, I compare the Logit specification with Eq. (3.15) to Eq. (3.14) by a likelihood ratio test.

$$Z_t = \left(1, \left|\Lambda_t - \bar{\Lambda}\right|\right)' \tag{3.15}$$

These results are shown in Table 3.13. In four of six stocks, I can reject the null hypothesis of symmetry adjustment with respect to dividend gap at the 10% level of significance. These four stocks (stock NY Times, Duquesne, Murphy and Midland) are much less likely to change the dividend in response to a positive gap, since managers are more reluctant to send the bad signals to the investors by lowering the dividends. That leads managers to postpone a dividend change even if external finance is costly and they then might lose the opportunity of investing on the projects paying above-market rates of return. Thus, I conclude these managers seem concern about the responses of investors to a dividend change; that is another possible explanation for dividend stickiness on these selected stocks.

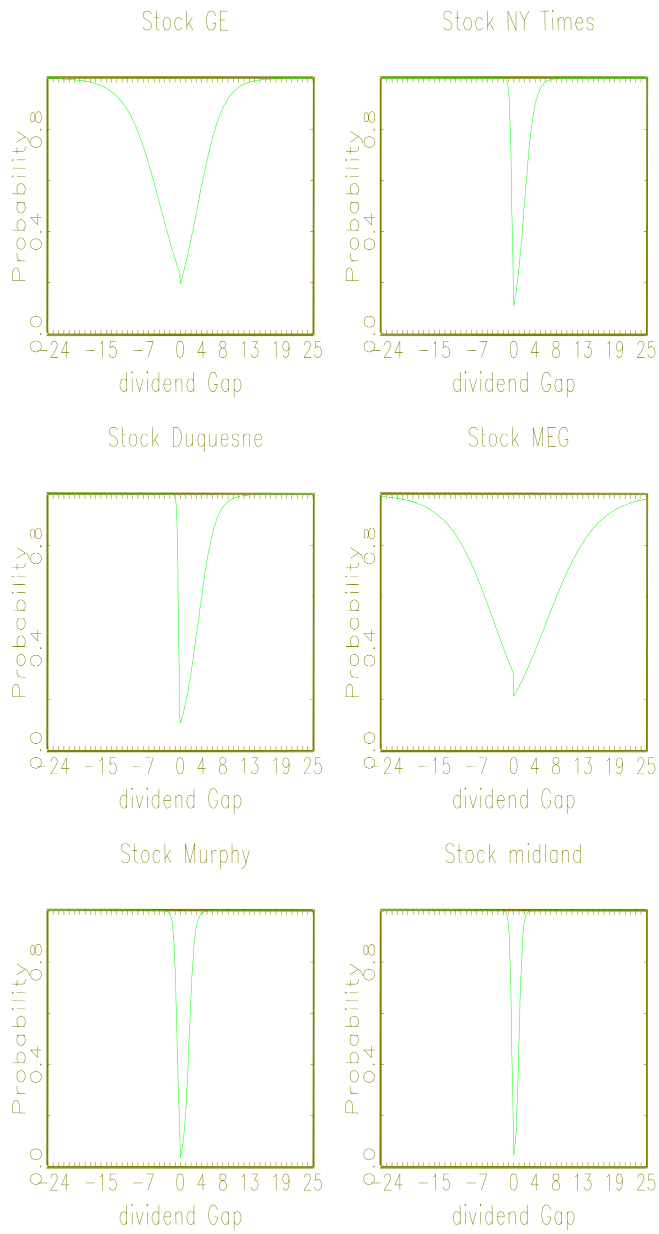

Fig. 3.5. Probability of a dividend change

Table 3.13
Test for significance of asymmetry in Logit specification

Stock	P-Value
GE	0.898
NY Times	0.010***
Duquesne	0.100*
MEG	0.514
Murphy	0.069*
Midland	0.016**

Notes: Table reports P-value. Asterisk (*) denotes statistically significant at the 10% level, Double-asterisk (**) denotes statistically significant at the 5% level, Triple-asterisk (***) denotes statistically significant at the 1% level.

3.7. Conclusions

The observed dividends on individual stocks show that dividends are sluggish and discrete. It is not consistent with the Lintner's stylized fact (1956), which dividend adjustments are assumed to change continuously. In this chapter, I examine three explanations to account for sticky and discrete dividends. These are menu costs (i.e. a constant adjustment cost), decision-making delays, and dividend adjustment asymmetry.

Following the Garrett and Priestley (2000) model and agency cost issue, the current gap between actual and target dividends should be a good predictor on the probability of a dividend change in the next period. The Dixit's menu-cost model (1991) seems appropriate to investigate the interpretations of sticky dividend. However, the estimates b_{MLE}, σ_{MLE} in the menu-cost model are larger than b_{direct} and σ_{direct}, since this model imputes much more uncertainty about the target dividends than is warranted by the data. Even the values of $\frac{b^2_{MLE}}{\sigma^2_{MLE}}$ appear to be some reasonable numbers given the interpretation of menu-cost model, I still cannot conclude this model is a fit specification for observed dividend process, since the estimated expected time interval of one cycle, $\frac{b^2_{MLE}}{\sigma^2_{MLE}}$, is non-rigid.

Although it is commonly believed that it is costly to change dividends, my results for Dixit's menu-cost model implies that the dividend process is not accurately described as the trade off between a constant adjustment cost of changing dividend and the deviation cost when the actual dividend moves away from target level. It seems more reasonable that the adjustment costs of changing dividend are associated with a magnitude of dividend deviation. Therefore, I perform an alternative specification, a quadratic adjustment cost model, to examine whether the adjustment cost is an important factor explaining slow dividend adjustment in the next chapter.

In this chapter, I find there is evidence of decision-making delays for selected stocks. That is, managers might need longer time to process the information about the stochastic structure of target dividends. That might be one possible explanation for dividend stickiness. Another important finding is the probability of a dividend change seems to be asymmetry. In such a case, managers are more likely to increase dividends on the negative gaps than change dividends on the positive gaps. It reflects managers are concerned about the responses of investors to dividend changes. The asymmetry pattern is another explanation in accounting for sticky dividends.

CHAPTER IV

THE ADJUSTMENT COST OF DYNAMIC BEHAVIOR OF DIVIDEND

4.1. Introduction

One of the important features in the stock market is the sluggish adjustment of dividends. However, few studies analyze the determinants of dividend smoothing. In the chapter III, I examined three possible explanations: menu-costs, decision-making delays, and dividend adjustment asymmetry to account for sticky dividends. Dixit's model is used to investigate whether the adjustment costs could explain the sticky dividends for some selected individual stocks. The adjustment costs in Dixit's specification remain unchanged irrespective the magnitude of deviation between current and previous dividend.[13] The empirical result suggests that Dixit's model cannot accurately describe the dividend process with a constant adjustment costs.

In this chapter, I analyze the dynamic dividend behavior of the aggregate stock market. I take another empirical look at adjustment costs as one possible explanation for slow adjustments of aggregate dividends. One alternative specification, a quadratic adjustment cost model, is used to examine whether adjustment costs can explain the slow adjustment process of aggregate dividends.

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[13] In the Dixit's model, managers are assumed to minimize the total loss resulting from the deviation of dividends from target levels and the constant adjustment cost of changing dividends, g.

$$E_{t_0}\left\{\sum_{i=1}^{\infty}\left[\left(\int_{t_{i-1}}^{t_i} e^{\beta t} k\,(d_{t_{i-1}} - d_t^*)^2\,dt + g\,e^{\beta t_i}\right]\right\}$$

Following Garrett and Priestley's model (2000), managers in setting dividends are assumed to minimize the loss resulting from the deviations of dividends from target levels. In addition, most managers avoid making changes in dividends since the potential adjustment costs could arise. In chapter III, the adjustment costs are assumed to be constant, but the empirical results imply that Dixit's model is not an appropriate model to describe the sluggish adjustment of dividends for individual stocks. Thus, in this chapter, the adjustment costs are assumed to be related to the magnitude of deviation between changes in dividends.

Since the quadratic adjustment cost model can incorporate the deviations of dividends from target levels and varying adjustment costs, this specification is set up to investigate whether the adjustment cost is one explanation for sluggish aggregate dividend in the stock market. The quadratic function can generate a series of dividend decisions to minimize the total discounted sum of adjustment loss in the long run. That could be used to assess the slow adjustment process of dividends. If the adjustment costs are assumed to be an important factor explaining slow aggregate dividend adjustment, then the relative weight factor, the cost of dividends deviating from target levels to the adjustment costs, should be smaller. That is, this chapter estimates the structural parameters (the relative weight factor and discount factor) of a dynamic dividend problem.

There are two important issues to consider when estimating the quadratic adjustment cost specification of dividends. First, the indexes (dividend, earnings or stock price) in stock market are nonstationary $I(1)$, and there is one cointegrating relation among these indexes (in the sense of Engle and Granger, 1987). Second, the error terms in the Euler equation are composite and correlated with the indexes. I find the two-step estimation procedure (proposed by Dolado, Galbraithand and Banerjee, 1991) can be used to reasonably estimate the structural parameters in the quadratic adjustment cost model even when the indexes in the stock market are nonstationary. The first step is to estimate the cointegrating regression between dividends and earnings (stock prices). The second step is to apply the GMM method to estimate the parameters in the Euler equation.

The rest of this chapter is organized as follows. In section 4.2 describes the quadratic adjustment cost model and derives the Euler equation. In section 4.3, describes the estimation of Euler equation. In section 4.4, describes the data. In section 4.5, reports the empirical results. Section 4.6, concludes.

4.2. The quadratic adjustment cost model

Sargent (1978) and Kennan (1979) were the first to estimate quadratic adjustment cost models. Kennan(1979) proposed a two-step estimation procedure to estimate the Euler equation, however, it was only applied to stationary variables. Delado et al. (1991) proposed alternative estimation strategies for the variables that are integrated of order one or two. Amano and Wirjanto (1997a, b) used this two-step estimation method to estimate the adjustment costs of imports in Canada and the United States, the adjustment costs of dynamic labor demand when the series are all nonstationary.

In the quadratic adjustment cost specification, the representative manager in the stock market is assumed to be rational and control dividends, d_t (measured in natural log units), to minimize the quadratic cost of adjusting dividends in the long run, given a log of target dividends.

$$\underset{d_{t+j}|_{j=0}^{\infty}}{Min}\ E_t \sum_{j=0}^{\infty} \beta^j \left[\vartheta (d_{t+j} - d^*_{t+j})^2 + (d_{t+j} - d_{t+j-1})^2 \right] \tag{4.1}$$

where E_t is the expectations operator conditional on the managers' information at time t, d_{t+j} is the log of dividend in period $t+j$, d^*_{t+j} is the log of target dividend in period $t+j$, and β is the discount rate, $0 < \beta < 1$. The parameter ϑ reflects the relative cost of deviating from the log of target dividend versus the cost of adjusting log of dividends, where $\vartheta > 0$.

The first-order necessary condition at time t in Eq. (4.1) is

$$\Delta d_t = \beta E_t \Delta d_{t+1} - (d_t - d^*_t) \tag{4.2}$$

The Euler equation is written as

$$E_{t+j} d_{t+j+1} + \frac{1+\vartheta+\beta}{\beta} d_{t+j} - \frac{1}{\beta} d_{t+j-1} = \frac{\vartheta}{\beta} E_{t+j} d^*_{t+j} \qquad j = 0,1,2... \tag{4.3}$$

The transversality condition

$$\lim_{T\to\infty} E_t \beta^T \left\{ (d_{t+T} - d^*_{t+T})^2 + (d_{t+T} - d_{t+T-1})^2 \right\} = 0 \tag{4.4}$$

I define $s \equiv t + j$

$$E_s d_{s+1} + \Omega E_s d_s - \frac{1}{\beta} E_s d_{s-1} = \frac{\vartheta}{\beta} E_s d^*_s. \tag{4.5}$$

where $\Omega = \dfrac{1+\vartheta+\beta}{\beta} = 1+\dfrac{\vartheta}{\beta}+\dfrac{1}{\beta} > 2$

I rewrite Eq. (4.5) as

$$\left[-B^{-2}+\Omega B^{-1}-\frac{1}{\beta}\right]E_s d_{s-1} = \frac{\vartheta}{\beta}E_s d_s^* \tag{4.6}$$

where the operator B is defined by $B^{-j}E_s d_s \equiv E_s d_{s+j}$ for all j

I multiply both sides by $-\beta$ to get:

$$\left[\beta B^{-2}-\beta\Omega B^{-1}+1\right]E_s d_{s-1} = -\vartheta E_s d_s^*. \tag{4.7}$$

Then I factor the polynomial $\left[\beta B^{-2}-\beta\Omega B^{-1}+1\right]$ as

$$\beta B^{-2}-\beta\Omega B^{-1}+1 = \beta(\lambda_1-B^{-1})(\lambda_2-B^{-1}) = (\beta B^{-2}-\beta(\lambda_1+\lambda_2)B^{-1}+\beta\lambda_1\lambda_2)$$

so that, I require

$$\lambda_1+\lambda_2=\Omega \tag{4.8}$$

$$\lambda_1\lambda_2=\frac{1}{\beta} \tag{4.9}$$

The above second equality establishes that $\lambda_2 = \dfrac{1}{\beta\lambda_1}$.

From Eq. (4.8) and Eq. (4.9), it is known that both λ_1 and λ_2 are positive and at least one of the pair is greater than one. I solve Eq. (4.8) and Eq. (4.9) to get:

$$\lambda_2 = \frac{\Omega \pm \sqrt{\Omega^2-4\beta}}{2}, \text{ and } \quad \lambda_1 = \frac{2}{\beta(\Omega \pm \sqrt{\Omega^2-4\beta})}$$

where $\Omega^2-4\beta>0$, so λ_1 and λ_2 are not complex numbers.

$$\beta(\lambda_1-B^{-1})(\lambda_2-B^{-1})E_s d_{s-1} = -\vartheta E_s d_s^* \tag{4.10}$$

I assume that one of the roots exceeds 1 (λ_2); the other necessarily is less than 1 (λ_1). In Eq. (4.10), I divide both sides by $\beta(\lambda_2 - B^{-1})$

$$(\lambda_1 - B^{-1})\, E_s\, d_{s-1} = \frac{-\vartheta}{\beta(\lambda_2 - B^{-1})} E_s\, d_s^*$$

$$= \frac{-\vartheta}{\beta\,\lambda_2} \frac{1}{(1 - \beta\,\lambda_1 B^{-1})} E_s\, d_s^* \tag{4.11}$$

Then, the above equation can be expressed as

$$-d_s + \lambda_1 d_{s-1} = -\vartheta\,\lambda_1 \sum_{i=0}^{\infty} (\lambda_1 \beta)^i\, E_s\, d_{s+i}^*$$

$$d_s = \lambda_1 d_{s-1} + \vartheta\,\lambda_1 \sum_{i=0}^{\infty} (\lambda_1 \beta)^i\, E_s\, d_{s+i}^* \tag{4.12}$$

Manager's problem at time *t* is to set d_t and devise a strategy for setting $\{d_{t+j}\}_{j=1}^{\infty}$ to minimize the discounted present value of the adjustment loss. Eq. (4.12) is a solution to the Euler equation for solving Eq. (4.1).

That is,

$$d_{t+j} = \lambda_1 d_{t+j-1} + \vartheta\,\lambda_1 \sum_{i=0}^{\infty} (\lambda_1 \beta)^i\, E_{t+j}\, d_{t+j+i}^* \tag{4.13}$$

Dividends at any period *t* are assumed to follow the stochastic process in Eq. (4.13) by seeing Eq. (4.12).

$$d_t = \lambda_1 d_{t-1} + \vartheta \lambda_1 \sum_{i=0}^{\infty} (\lambda_1 \beta)^i\, E_t\, d_{t+i}^* \tag{4.14}$$

where λ_1 is the smaller stable root. The log of dividend at period *t* is set as a weight of previous log of dividend and the expectations sum of discounted future fraction log of target dividends.

Eq. (4.14) can also be rewritten as the following,[14]

$$d_t = \lambda_1 d_{t-1} + (1-\lambda_1)(1-\beta\lambda_1)\sum_{i=0}^{\infty}(\lambda_1\beta)^i E_t d^*_{t+i} \tag{4.15}$$

Next, I specify the level target dividends, D_t^*. One of the Lintner' list of stylized facts (1956), target dividends are specified as some percentage of earning Y_t. Marsh and Merton (1987) suggested that the stock prices P_t could be one indicator to determine the target dividends. Therefore, I specify these two different relationships between level target dividend D_t^* and level earnings Y_t / stock prices P_t. The target variable in the quadratic adjustment cost specification is always assumed to be linearly related with some exogenous variables (Kennan, 1979; Dolado et al. , 1991; Amano and Wirjanto ,1997a, b). Thus, the level target dividends, D_t^*, here are specified as Eq. (4.16),

$$D_t^* = r\Gamma_t + \upsilon_t \tag{4.16}$$

where Γ_t is either level of earnings Y_t or level of stock prices P_t, r is a constant parameter, the long-run target payout ratio. υ_t is the error term known by managers at period *t*.

I take log of Eq. (4.16)

$$\log D_t^* = \log r + \log\Gamma_t + \log\upsilon_t \tag{4.17}$$

Eq. (4.17) is written as

$$d_t^* = \alpha + H_t + \nu_t \tag{4.18}$$

---

[14] In Eq. (4.7), λ_1 is the smaller stable root for the Euler equation, that is, $\beta\lambda_1^2 - \beta\Omega\lambda_1 + 1 = 0$. I therefore get $\vartheta\lambda_1 = (1-\lambda_1)(1-\beta\lambda_1)$.

where $d_t^* = \log D_t^*$, $\alpha = \log r$, $H_t = \log \Gamma_t$, and $\nu_t = \log \upsilon_t$, ν_t is assumed to be a white noise process.

H_t is assumed to follow an independent random walk (see Table 4.1, $y_t = \log Y_t$ or $p_t = \log P_t$ is consistent with this assumption), that is,

$$(1-L)H_t = a + e_t \tag{4.19}$$

where a is a constant and e_t is a white noise term.

Table 4.1
Random walk test (Augmented-Dickey-Fuller test without lagged terms)

Variable	Lag Order	ADF t-statistic	Critical Value (5%)
y_t	0	1.729155	-1.941023
p_t	0	1.559500	-1.941023

Notes: Critical values are at 5% significance level.
y_t denotes the log of earnings, p_t denotes the log of stock prices.
* indicates rejection of null at 5 % critical value.

I replace Eq. (4.18) and Eq. (4.19) into Eq. (4.15) and get,

$$(1-\lambda_1 L)d_t = (1-\lambda_1)\alpha + (1-\lambda_1)H_t + (1-\lambda_1)a + (1-\lambda_1)(1-\beta\lambda_1)\nu_t \tag{4.20}$$

In Eq. (4.20), the smaller stable root λ_1 lies inside the unit circle, H_t variable is $I(1)$, the white noise ν_t is $I(0)$. Then d_t must follow $I(1)$ process. Eq. (4.20) implies the cointegration restriction between d_t and H_t in this quadratic adjustment cost model.

I rearrange Eq. (4.20) and find

$$d_t = \alpha + a + H_t + \kappa_t \tag{4.21}$$

where $\kappa_t = \frac{1}{(1-\lambda_1 L)}\left[(1-\lambda_1)(1-\beta\lambda_1)\nu_t - \lambda_1 e_t\right]$. The term κ_t clearly is $I(0)$ since ν_t and e_t are all $I(0)$. From Eq. (4.21), it asserts that d_t and H_t are cointegrated with cointegrating vector $(1,-1)$.

To get an Euler equation that can be estimated, I next substitute Eq (4.18) into Eq. (4.2) to obtain,

$$\begin{aligned}\Delta d_t &= \beta E_t \Delta d_{t+1} - \vartheta(d_t - \alpha - H_t) + \vartheta \nu_t \\ &= \beta\Delta d_{t+1} + \beta(E[\Delta d_{t+1} \mid I_t] - \Delta d_{t+1}) - \vartheta(d_t - \alpha - H_t) + \vartheta\nu_t \\ &= \beta\Delta d_{t+1} - \vartheta(d_t - \alpha - H_t) + \beta\, u_{t+1} + \vartheta\nu_t \qquad (4.22)\end{aligned}$$

where $E_t \Delta d_{t+1}$ is assumed to be realized by $\Delta d_{t+1} + u_{t+1}$, u_{t+1} is the expectation error ($E[\Delta d_{t+1} \mid I_t] - \Delta d_{t+1}$). Under rational expectation, $E(u_{t+1}) = 0$.

Eq. (4.22) then can be rewritten as

$$\Delta d_t = \beta\Delta d_{t+1} - \vartheta(d_t - \alpha - H_t) + \eta_{t+1} \qquad (4.23)$$

where $\eta_{t+1} = \beta u_{t+1} + \vartheta\nu_t$. Under rational expectation, $E_t \eta_{t+1} = 0$. As noted earlier, since d_t and H_t are cointegrated in Eq. (4.23), I use the two-step estimation procedures (suggested by Dolado, Galbraith and Banerjee, 1991; Amano and Wirjanto, 1997a, b) to estimate the structure parameters β, ϑ in Eq. (4.23).

4.3. The estimation of an Euler equation

In the first step of Dolado et al. (1991) estimation procedures, the long- run target payout ratio α is estimated by the cointegrating regression:

$$d_t = \alpha + H_t + \xi_t \tag{4.24}$$

where $\xi_t = \frac{1}{(1-\lambda_1 L)}\left[(1-\beta\,\lambda_1)(1-\lambda_1)\,\nu_t - \lambda_1 e_t\right]$

Since log dividends and log of earnings (log of stock prices) are both $I(1)$ in Eq. (4.24), as noted earlier, it allows one cointegrating vector $(1,-1)$ between log of dividends and log of earnings (log of stock prices). From Eq (4.24), let Θ_t be the difference between d_t and H_t.

$$\Theta_t = d_t - H_t \tag{4.25}$$

I estimate the target dividend payout out ratio α by finding the expectation of the difference, $E(\Theta_t)$ in Eq. (4.25).

Eq. (4.23) can be written as

$$\Delta d_t = \beta \Delta d_{t+1} - \vartheta Z_t + \eta_{t+1} \tag{4.26}$$

where $Z_t = d_t - \alpha - H_t$.

In the second step of the estimation procedures (Dolado et al., 1991), since Δd_{t+1} and Z_t are correlated with the error term η_{t+1} and all the variables are $I(0)$ in Eq. (4.26), Dolado et al. (1991) suggested to use instrumental variable method to estimate the parameters in Eq. (4.26). Thus, the Generalized Method of Moments (Hansen, 1982) is used to estimate the parameters under conditions about the error structure in Eq. (4.26) (Amano and Wirjanto, 1997a, b). I can find one set of instruments I_t such that the moment condition $E(\eta_{t+1} | I_t) = 0$.

The variable $\hat{Z}_t$ is estimated by using the first stage, Eq. (4.26) can be written as,

$$\Delta d_t = \beta \Delta d_{t+1} - \vartheta(\hat{Z}_t) + \eta_{t+1} \tag{4.27}$$

where $\hat{Z}_t = d_t - \hat{\alpha} - H_t$, $\hat{\alpha}$ is the expectation of the difference between d_t and H_t, $E(\Theta_t)$, in Eq. (4.25) . Dolado et al. (1991) suggested the discount rate β and the relative weight ϑ in Eq. (4.27) could be directly estimated by the generalized instrumental variable method. GMM procedure here is used to estimate the structure parameters β and ϑ in Eq. (4.27). The instruments include a constant and the lag values of Δd_t.

4.4. Data

The monthly data of S&P 500 are used from 1871: Jan to 2003: Sep. I use the natural log of dividend, earnings and stock price. The time series (dividends, earnings, and stock prices) in levels and in log are shown in Figures 4.1-1, 4.1-2, 4.2-1 and 4.2-2. The variables are examined by using Augmented-Dickey-Fuller test. The test statistics for the variables are reported in Table 4.2. I find that the variables (log dividends, log earnings, and log price) fail to reject the null of nonstationarity. That is, d_t, y_t and p_t all follow $I(1)$ processes; the first differences follow $I(0)$. Since log of stock prices (log of earnings) and log of dividends are all $I(1)$, then these two variables (log of stock prices with log of dividends, or log of earnings with log of dividends) should have one cointegrating relationship. Tables 4.3-1 and 4.3-2 reports the result of the Johansen type likelihood ratio tests (1995). It indicates that the existence of one cointegrating vector between log of dividends and log of earnings (log of stock prices).

Table 4.2
Test of the time series data in Augmented-Dickey-Fuller tests.

Variables	ADF lags	ADF t-statistic	Critical value
d_t	2	-1.864509	-2.863155
y_t	2	-2.329963	-2.863155
p_t	1	-1.113340	-2.863153
Δd_t	1	-16.47575*	-2.863153
Δy_t	1	-12.42056*	-2.863153
ΔP_t	0	-30.12070*	-2.863152

Notes: Critical values are at 5% significance level.
y_t denotes the log of earnings, p_t denotes the log of stock prices.
* indicates rejection of null at 5 % critical value.

4.5. The empirical results

As mentioned in section 4.3, I first estimate the long-run parameter α in Eq. (4.23). In Eq. (4.25), Θ_t is the difference between log of dividends and log of earnings (log of stock prices). Table 4.4 summarizes the results of unit root tests on Θ_t. This variable appears stationary. It implies that there is one cointergrating relationship $(1,-1)$ between log of dividends and log of earnings (log of stock prices). α is estimated by finding the expectation of the difference between d_t and H_t. An important issue is the specification of target dividends.

If target dividends are related to earnings--- $D_t^* = rY_t$,

$$\hat{\alpha} = E(\Theta_t = d_t - y_t) = -0.5115$$

That is, $D_t^* = 0.5996Y_t$ $(r = e^{\alpha})$. It interprets that the long-run target payout ratio r is 0.5996; which means target dividends are 59.96 % of earnings. The time series in levels of actual dividends and the estimated target dividends are shown in Figure 4-3-1.

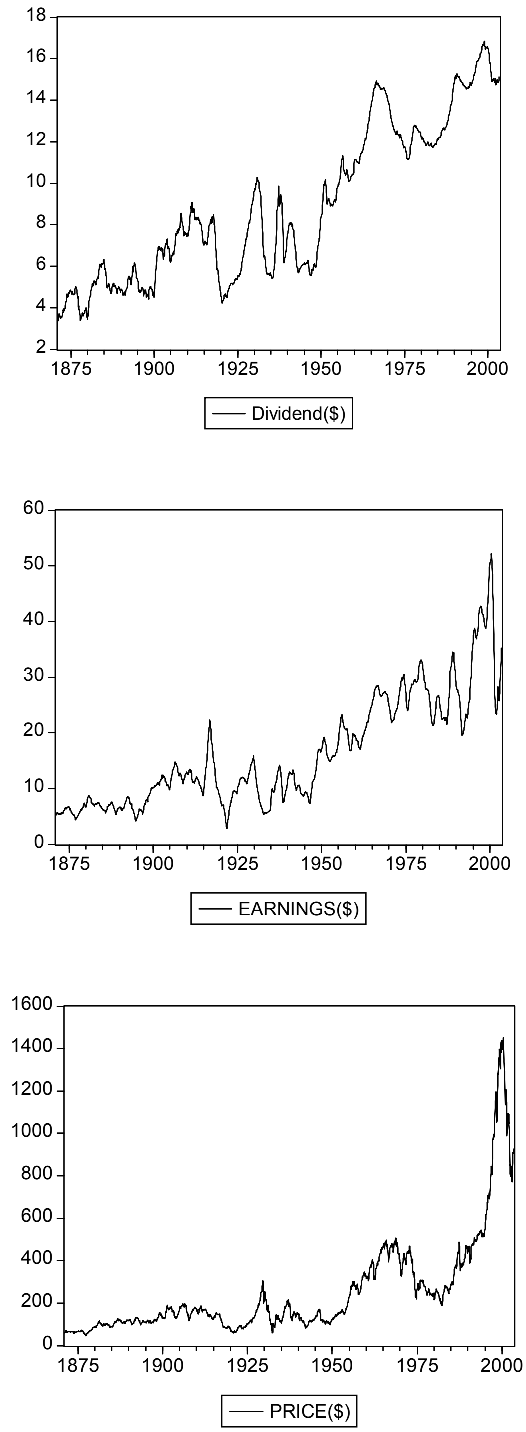


Fig. 4.1-1. Time series used in levels: sample 1871:01-2003:09

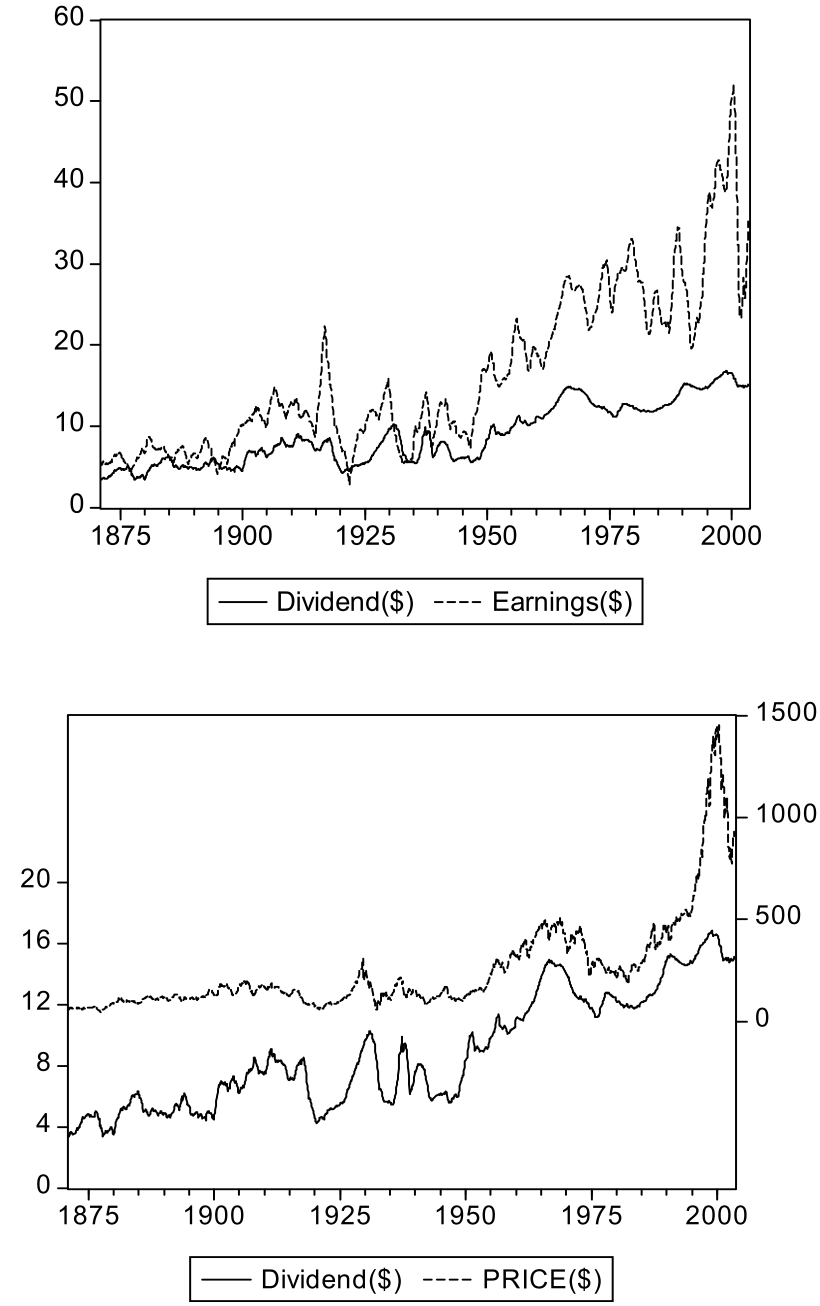


Fig. 4.1-2. Time series used in levels dividend and earnings (stock prices): sample 1871:01-2003:09

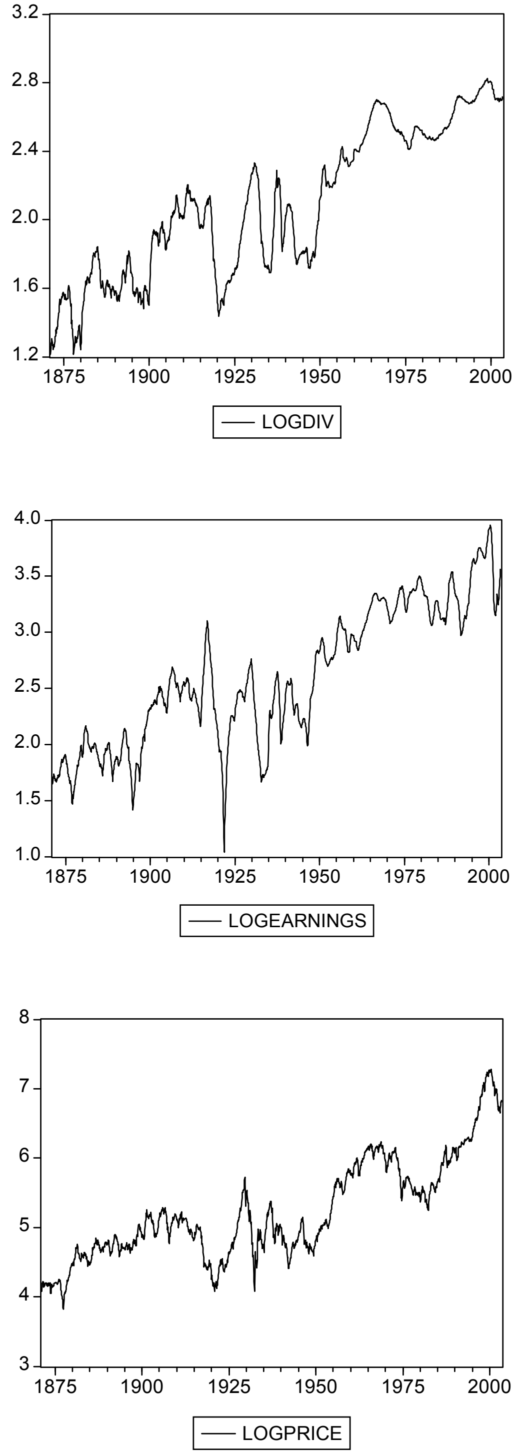
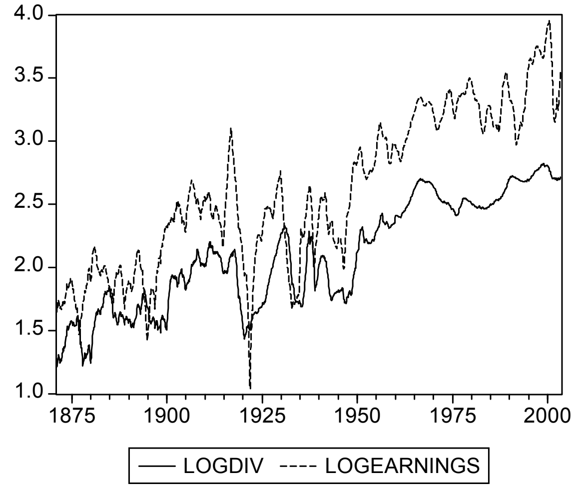


Fig. 4.2-1. Time series used in Log: sample 1871:01-2003:09



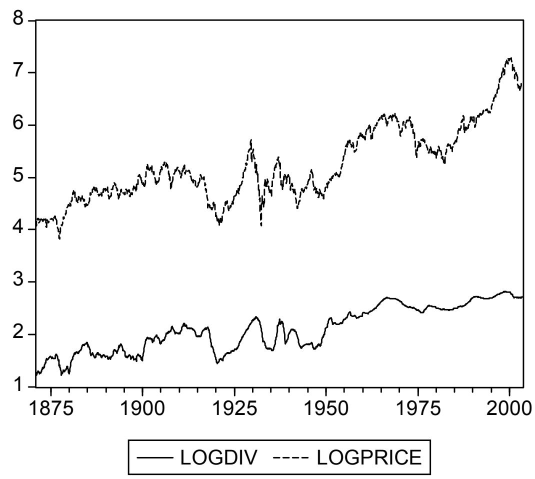


Fig. 4.2-2. Time series used in Log dividend and Log earnings (stock prices) sample 1871:01-2003:09

Table 4.3-1
Johansen test for the cointegration (log of dividends and log of earnings)

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.029561	48.17483	12.53	16.31	None **
0.000330	0.523712	3.84	6.51	At most 1

Notes: *(**) denotes rejection of the hypothesis at the 5%(1%) level
Likelihood Ratio test indicates one cointegrating equation at both 5% and 1% levels

Table 4.3-2
Johansen test for the cointegration (log of dividends and log of stock prices)

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.013628	22.77205	12.53	16.31	None **
0.000618	0.981472	3.84	6.51	At most 1

Notes: *(**) denotes rejection of the hypothesis at the 5%(1%) level
Likelihood Ratio test indicates one cointegrating equation at both 5% and 1% levels

If target dividends are related to stock prices--- $D_t^* = r P_t$,

$$\hat{\alpha} = E(\Theta_t = d_t - p_t) = -3.1423$$

That is, $D_t^* = 0.0432 P_t$. It implies that the long-run target payout ratio r is 0.0432; which means target dividends are 4.32 % of stock prices. The time series in levels of actual dividends and the estimated target dividends are shown in Figure 4.3-2.

Table 4.4
Test of Θ_t in Augmented-Dickey-Fuller test with drift and trend

Variable	ADF lags	ADF t-statistic	Critical value
$\Theta_t = d_t - y_t$	13	-6.433970*	-3.412658
$\Theta_t = d_t - p_t$	13	-6.433970*	-3.412658

Notes: Critical values are at 5% significance level.
y_t denotes the log of earnings, p_t denotes the log of stock prices.
* indicates rejection of null at 5 % critical value.

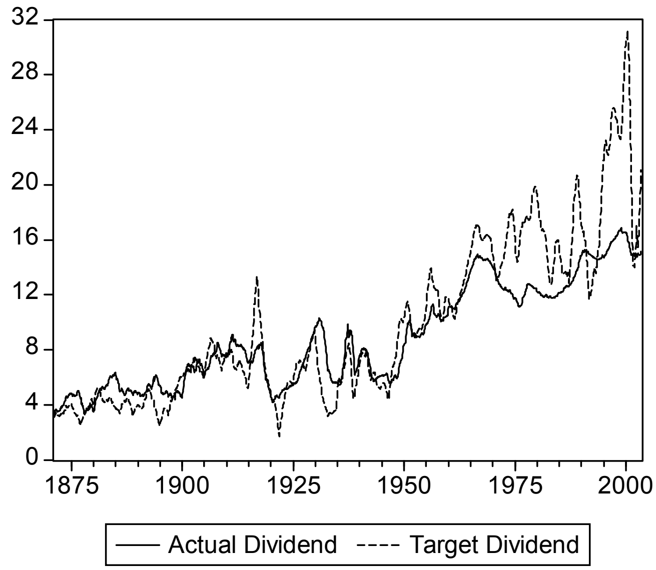


Fig. 4.3-1. Actual dividend and estimated target dividend (related to earnings) in levels: sample 1871:01-2003:09

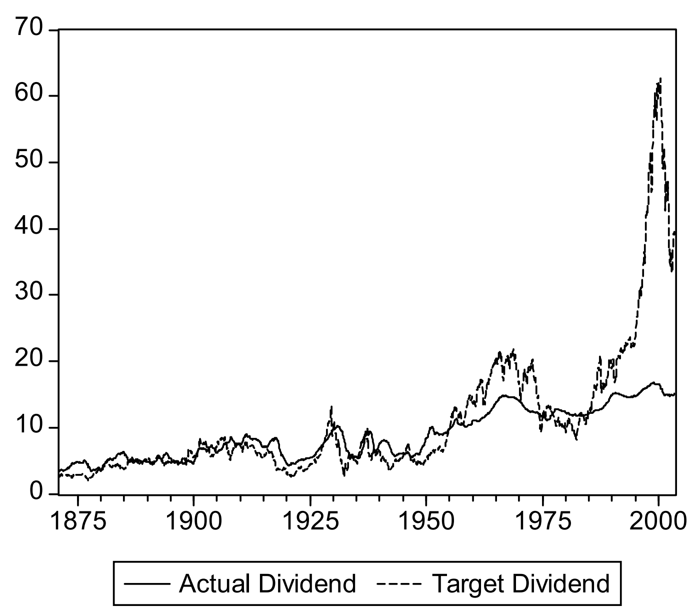


Fig. 4.3-2. Actual dividend and estimated target dividend (related to stock prices) in levels: sample 1871:01-2003:09

In the next step, the generalized instrumental variables method is used to estimate the structural parameters β, ϑ in Eq. (4.27). I use Hansen's GMM procedure to estimate the structure parameters. The instruments include a constant, lags of Δd_t at time *t-1* to *t-4*: I_4^1, the superscript 1 corresponds to the first lagged value and the subscript 4 represents the fourth lagged value.

First, I estimate both the structural parameters β and ϑ by directly estimating the Euler equation Eq. (4.27). The results are reported in Table 4-5-1 (target dividends are related to earnings), and Table 4.5-2 (target dividends are related to stock prices). Since there are more instruments than parameters to be estimated in this equation, the validity of the model is tested by using Hansen's J-test for over-identifying restrictions. In Tables 4.5-1 and 4.5-2, the J-test results are not significant at 5 % level, that is, J-tests are unable to reject the validity of the over-identifying restrictions. In Table 4.5-1, the estimated relative cost weight ϑ is –0.0235; it is not reasonable since ϑ is assumed to be positive.

Table 4.5-1
The estimate of the Euler equation in the case of $D_t^* = rY_t$

Parameter	I_4^1
β	1.433449**
	(0.326134)
ϑ	-0.023537
	(0.041376)
J-test	1.6627
P-value	0.6453

Note: Standard errors are in the parentheses. Asterisk (*) denotes statistically significant at the 10% level. Double-asterisk (**) denotes statistically significant at the 5% level. Tri-asterisk (***) denotes statistically significant at the 1% level.

Table 4.5-2
The estimate of the Euler equation in the case of $D_t^* = r\, p_t$

Parameter	I_4^1
β	1.251774 (0.814406)
ϑ	0.003402 (0.227384)
J -test	1.7311
P-value	0.6300

Note: Standard errors are in the parentheses. Asterisk (*) denotes statistically significant at the 10% level. Double-asterisk (**) denotes statistically significant at the 5% level. Tri-asterisk (***) denotes statistically significant at the 1% level.

In Table 4.5-2, the estimated discount factor β is 1.2518 which is outside unit interval and does not lie in the reasonable ranges for the discount factor. Gregory, Pagan and Smith (1993) pointed that it is difficult to identify β when the target variable H_t follows $I(1)$ in the Euler equation. That could explain the unreasonable estimates in the Euler equation. Thus, Amano and Wirjanto (1997a, b) first fixed the parameter β and then estimate the parameter ϑ in the Euler equation when the target variable follows $I(1)$ process.

Hence, I select the parameter values from the set $\beta \in \{$ 0.999, 0.998, 0.997, 0.996, 0.995, 0.990, 0.985, 0.980 $\}$ and estimate the relative cost weight ϑ in Eq. (4.27). Table 4-6-1 (target dividends are related to earnings), and Table 4-6-2 (target dividends are related to stock prices) show the results. In the Table 4-6-1, I cannot reject the validity of the over-identifying restrictions by using J-tests based on the alternative parameter value for β; the estimates of the relative cost weight ϑ corresponding to β(0.999, 0.998, 0.997, 0.996, 0.995, 0.99, 0.985, 0.98) are all significant at the 1 %

level and range between 0.0241 and 0.0266. It implies that the adjustment costs are about forty-fold more important than the deviation cost between actual dividend and target level in determining the dividend payout. It suggests the adjustment cost is a significant factor influencing the sluggish dividend adjustments. The estimates of ϑ lie within the narrow rages between 0.0241 and 0.0266 and are statistically significant. Since the estimates of ϑ appear to be insensitive to the values of the discount parameters—0.999---0.980, it is appropriate to estimate ϑ over a range of reasonable values of the discount factor β.

In Table 4.6-2, none of J-tests rejects the validity of the over-identifying restrictions. The estimated ϑ corresponding to β (0.999, 0.998, 0.997, 0.996, 0.995, 0.99, 0.985, 0.98) ranges between 0.0776 and 0.0835. It implies that the adjustment costs are about fourteen-fold more important than the deviation cost between actual dividend and target level when managers determine the dividends. The estimates ϑ also appear to be insensitive over a range of discount parameter β 0.999---0.980, although the test values are not statistically significant.

I also estimate the smaller stable root λ_1. λ_1 is solved by calculating the quadratic function : $\beta\lambda_1^2 - (\beta + \vartheta + 1)\lambda_1 + 1 = 0$. The parameter $\hat{\vartheta}$ is set equal to the estimates presented in Tables 4.6-1 and 4.6-2 corresponding to β (0.999, 0.998, 0.997, 0.996, 0.995, 0.99, 0.985, 0.98). Since the stable root λ_1 satisfies the condition: $\vartheta\lambda_1 = (1-\lambda_1)(1-\beta\lambda_1)$, it is found there is one negative relation between ϑ and λ_1. It implies that the adjustment costs will get larger when the stable root is approaching unity. The estimated parameters λ_1 are reported in Tables 4.7-1 and 4.7-2. In Table 4.7-1, λ_1 ranges between 0.8566 and 0.8573. In Table 4.7-2, λ_1 ranges between 0.7579 and 0.7562. These values are all large (close to unity); it implies adjustment costs of changing dividends are high. Thus, it also implies that the estimates ϑ are consistent with the model, even although I first fix the discount factor β.

Table 4.6-1:
The estimate of ϑ in the Euler equation in the case of $D_t^* = rY_t$

β	ϑ
$\beta = 0.999$	0.024140*** (0.009471)
J -test	4.4365
P-value	0.3501
$\beta = 0.998$	0.024268*** (0.009497)
J -test	4.4440
P-value	0.3492
$\beta = 0.997$	0.024395*** (0.009524)
J -test	4.4517
P-value	0.3483
$\beta = 0.996$	0.024523*** (0.009550)
J -test	4.4589
P-value	0.3475
$\beta = 0.995$	0.024651*** (0.009576)
J -test	4.4663
P-value	0.3466
$\beta = 0.990$	0.025293*** (0.009710)
J -test	4.5030
P-value	0.3422
$\beta = 0.985$	0.025940*** (0.009848)
J -test	4.5392
P-value	0.3379
$\beta = 0.980$	0.026591*** (0.009989)
J -test	4.5747
P-value	0.3338

Notes: Standard errors are in the parentheses. Asterisk (*) denotes statistically significant at the 10% level. Double-asterisk (**) denotes statistically significant at the 5% level. Tri-asterisk (***) denotes statistically significant at the 1% level.

Table 4.6-2:
The estimate of ϑ in the Euler equation in the case of $D_t^* = r\,P_t$

β	ϑ
$\beta = 0.999$	0.077605 (0.061111)
J-test	1.2880
P-value	0.8634
$\beta = 0.998$	0.077917 (0.061294)
J-test	1.2852
P-value	0.8639
$\beta = 0.997$	0.078229 (0.061477)
J-test	1.2824
P-value	0.8644
$\beta = 0.996$	0.078540 (0.061659)
J-test	1.2796
P-value	0.8648
$\beta = 0.995$	0.078851 (0.061841)
J-test	1.2768
P-value	0.8653
$\beta = 0.990$	0.080400 (0.062747)
J-test	1.2633
P-value	0.8676
$\beta = 0.985$	0.081937 (0.063641)
J-test	1.2505
P-value	0.8697
$\beta = 0.980$	0.083467 (0.064535)
J-test	1.2381
P-value	0.8718

Notes: Standard errors are in the parentheses. Asterisk (*) denotes statistically significant at the 10% level. Double-asterisk (**) denotes statistically significant at the 5% level. Tri-asterisk (***) denotes statistically significant at the 1% level.

Table 4.7-1:
The estimate of λ_1 in the Euler equation in the case of $D_t^* = rY_t$

β, ϑ	λ_1
$\beta = 0.999$ $\vartheta = 0.024140$	0.8566
$\beta = 0.998$ $\vartheta = 0.024268$	0.8567
$\beta = 0.997$ $\vartheta = 0.024395$	0.8567
$\beta = 0.996$ $\vartheta = 0.024523$	0.8568
$\beta = 0.995$ $\vartheta = 0.024651$	0.8568
$\beta = 0.990$ $\vartheta = 0.025293$	0.8570
$\beta = 0.985$ $\vartheta = 0.025940$	0.8572
$\beta = 0.980$ $\vartheta = 0.026591$	0.8573

Table 4.7-2:
The estimate of λ_1 in the Euler equation in the case of $D_t^* = r\,P_t$

β, ϑ	λ_1
$\beta = 0.999$ $\vartheta = 0.077605$	0.7579
$\beta = 0.998$ $\vartheta = 0.077917$	0.7578
$\beta = 0.997$ $\vartheta = 0.078229$	0.7577
$\beta = 0.996$ $\vartheta = 0.078540$	0.7575
$\beta = 0.995$ $\vartheta = 0.078851$	0.7575
$\beta = 0.990$ $\vartheta = 0.080400$	0.7570
$\beta = 0.985$ $\vartheta = 0.081937$	0.7566
$\beta = 0.980$ $\vartheta = 0.083467$	0.7562

4.6. Conclusions

In this chapter, I use a quadratic adjustment cost model to examine whether the adjustment cost is a possible explanation for slow adjustment of aggregate dividend. I set up the quadratic adjustment cost specification and derive the dynamic dividend adjustment process. One two-step estimation procedure (proposed by Dolado, Galbraithand and Banerjee, 1991; Amano and Wirjanto, 1997a, b) is used to estimate the structural parameters β and ϑ in the quadratic adjustment cot model.

I use S&P 500 index as the data. In the first stage of Dolado et al. procedure (1991), I find the long-run target payout ratio r is about 0.5996 if target dividends are related to earnings; r is 0.0432 if target dividends are related to stock prices. In the second stage, when I estimate the discount factor β and the relative cost weight ϑ by directly estimating the Euler equation, I find the estimated cost weight ϑ is negative in the case of $D_t^* = rY_t$. The estimated discount factor β is outside of unit interval in the case of $D_t^* = rP_t$. These estimates are not all reasonable. Thus, I select the parameter values from the set $\beta \in \{ 0.999, 0.998, 0.997, 0.996, 0.995, 0.990, 0.985, 0.980 \}$ and estimate the relative weight ϑ. An important issue is the specification of target dividends. If target dividends are related to earnings, then the empirical results suggest that the adjustment costs are about forty-fold more important than the deviation costs between the actual dividend and the target level in determining the dynamic dividend adjustment process. This implies that the adjustment cost might be one possible explanation for slow dividend adjustment. If target dividends are specified as proportion to the stock prices, the estimates ϑ imply similar conclusions with the estimates in the earnings case; although the results are not statistically significant.

In summary, I conclude that the quadratic adjustment cost model reasonably describe the dynamic dividend adjustment process for S&P 500 when the discount factor is fixed. Thus, the adjustment costs might be one possible explanation for slow adjustment process of aggregate dividends.

CHAPTER V

CONCLUSIONS

In this dissertation, I investigate the sluggish adjustment process of dividend payment in the stock market. First, I focus on the sticky and discrete adjustment of dividends for the individual stocks. Second, I analyze the sluggish adjustment of dividends in the aggregate stock market.

A casual investigation of observed dividends for individual stocks shows that dividends are sluggish and discrete, this is not consistent with the Lintner's stylized fact (1956), in which dividend adjustments are assumed to change continuously. Thus, I examine three possible explanations to account for sticky and discrete dividends: menu-costs, decision-making delays, and dividend adjustment asymmetry.

I reject the menu-cost model as an accurate description of the dividend adjustment process. The empirical results imply that decision-making delays and dividend adjustment asymmetry might be possible explanations for some individual stocks.

It is still believed that it is costly to change dividend even though the menu-cost model implies that the dividend process is not accurately described as the trade off between a constant adjustment cost of changing dividend and the deviation cost of dividend from target level. Therefore, I perform one alternative specification, quadratic adjustment cost model, to examine whether the adjustment cost is an important factor explaining the slow dividend adjustment.

The quadratic adjustment cost specification takes the magnitude of deviation between changes in dividends into account. I derive a dynamic dividend adjustment process and apply a two-step methodology to estimate the structural parameters in the Euler equation. The empirical result implies adjustment cost might be a significant explanation of slow dividend adjustment for S&P 500.

REFERENCES

Amano, R.A., Wirjanto, T.S., 1997a. Adjustment costs and import demand behavior evidence from Canada and the United States. Journal of International Money and Finance 16(3), 461-475.

Amano, R.A., Wirjanto T.S., 1997b. An empirical study of dynamic labor demand with integrated forcing process. Journal of Macroeconomics 19(4), 697-715.

Cruthley, C., Hansen, R., 1989. A test of the agency theory of managerial ownership, corporate leverage, and corporate dividends. Financial Management 18(4), 36-46.

Cyert, R., Kang, S., Kumar, P., 1996. Managerial objectives and firm dividend policy: a behavioral theory and empirical evidence. Journal of Economic Behavior and Organization 31, 157-174.

Davis, M.C., Hamilton J.D., 2004. Why are prices sticky? The dynamics of wholesale gasoline prices. Journal of Money, Credit, and Banking 36(1), 17-38.

Dixit, A., 1991. Analytical approximations in models of hysteresis. Review of Economic Studies 58, 141-151.

Dolado, J., Galbraith, J.W., Banerjee, A., 1991. Estimating intertemporal quadratic adjustment cost models with integrated series. International Economic Review 32(4), 919-936.

Engle, R.F., Granger, C.W.J., 1987. Cointegration and error correction: representation, estimation and testing. Econometrica 55, 251-276.

Engle, R.F., Russell J., 1998. Autoregressive conditional duration: a new model for irregularly spaced transaction data. Econometrica 66, 1127-1162.

Esterbrok, F.H., 1984. Two agency cost explanations of dividends. American Economic Review 74, 650-659.

Fama, E.F., Harvey B., 1968. Dividend policy: an empirical analysis. Journal of the American Statistical Association 63, 1132-1161.

Garrett, I., Priestley, R., 2000. Dividend behavior and dividend signaling. Journal of Financial and Quantitative Analysis 35(2), 173-189.

Gregory, A.W., Pagan, A.R., Smith G.W., 1993. Estimating linear quadratic models with integrated processes. In: Phillips, P.C., (Ed.), Essays in Honour of Rex Bergstrom. Blackwell, Cambridge, UK.

Hamilton, J.D., Jorda O., 2002. A model of the federal funds rate target. Journal of Political Economy 110, 1135-1166.

Hansen, L.P., 1982. Large sample properties of generalized method of moments estimators. Econometrica 50, 1029-1054.

Hansen, P. S., 1999. Frequent price changes under menu costs. Journal of Economic Dynamics and Control 23, 1065-1076.

Healy, PM., Palepu, K.G., 1988. Earnings information conveyed by dividend initiations and omissions. Journal of Financial Economics 21(2), 149-75.

Johansen, S., 1995. Likelihood-based inference in cointegrated vector autoregressive models. Oxford University Press, New York.

Kao, C., Wu, C., 1994. Rational expectations, information signaling and dividend adjustment to permanent earnings. Review of Economics and Statistics 76(3), 490-502.

Kennan, J., 1979. The estimation of partial adjustment models with rational expectations. Econometrica 47, 1441-1455

Kumar P., Lee B., 2001. Discrete dividend policy with permanent earnings. Financial management Autumn, 55-76.

Lintner, J., 1956. Distribution of incomes of corporations among dividends, retained earnings, and taxes. American Economic Review 46, 47-113.

Marsh, T.A., Merton, R.C., 1987. Dividend behavior for the aggregate stock market. Journal of Business 60(1), 1-40.

Michaely, R., Thaler, R.H., Womack, K.L., 1995. Price reactions to dividend initiations and omissions: overreaction or drift? Journal of Finance 50(2), 573-608.

Rozeff, M.S., 1982. Growth, beta and agency costs as determinants of dividend payout ratios. The Journal of Financial Research 5(3), 249-259.

Sargent, T., 1978. Estimation of dynamic labor demand schedules under rational expectations. Journal of Political Economy 86, 1009-1044.

Schwarz, G., 1978. Estimating the dimension of a model. Annals of Statistics 6, 461-464.

APPENDIX

Suppose managers decide to change the dividend to $d(t_i) = d^*(t_i)$ at any quarter t_i, when $\left|d_{t_{i-1}} - d^*_{t_i}\right| = b$, then the probability which the dividend changes between *t* and *t+1* by the probability, either $d_t - d^*_{t+1} > b$, or $d_t - d^*_{t+1} < b$.

The upper bound $d_t - d^*_{t+1} > b$:

$$\text{Prob}\left[d_t - d^*_{t+1} > b\right]$$

$$= \text{Prob}\left[d_t - d^*_t - b > d^*_{t+1} - d^*_t\right]$$

$$= \text{Prob}\left[\frac{d_t - d^*_t - b}{\sigma} > \frac{d^*_{t+1} - d^*_t}{\sigma}\right]$$

$$= \text{Prob}\left[\frac{d_t - d^*_t - b}{\sigma} > Z\right]$$

$$= \Phi\left(\frac{d_t - d^*_t - b}{\sigma}\right) \tag{A-1}$$

where Z follows standard normal distribution $N(0,1)$, and Φ is the cumulative distribution function of a standard normal variable.

Similarly, the lower bound we have:

$$\text{Prob}\left[d_t - d^*_{t+1} < b\right] = 1 - \Phi\left(\frac{d_t - d^*_t + b}{\sigma}\right) \tag{A-2}$$

From Eq. (A-1) and Eq. (A-2), the probability of a change in dividends between quarter *t* and *t+1*, $h\left[d_t, d^*_t\right]$, can be approximated by

$$h\left[d_t, d^*_t\right] = \Phi\left(\frac{d_t - d^*_t - b}{\sigma}\right) + 1 - \Phi\left(\frac{d_t - d^*_t + b}{\sigma}\right) \tag{A-3}$$

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